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Francesco Caselli, Alexander Ludwig, and Rick van der Ploeg

No Brainers and Low-Hanging Fruit in National Climate Policy

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Edited by Francesco Caselli,
Alexander Ludwig
and Rick van der Ploeg

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Foreword

Countries worldwide have pledged to combat climate change and reduce greenhouse gas emissions, yet real concerns exist that targets will not be met and aspirations for the 2015 Paris agreement will fall short. In order to guarantee that world climate goals are achieved, and that the world economy thus reaches net zero emissions of greenhouse gases, effective and feasible policies must be implemented post haste.

This eBook, with contributions from economists working in more than 18 countries, provides timely and concise recommendations on achievable and efficient climate change policies that can be fast-tracked into implementation. Authors discuss which policies will have the fastest and/or largest cumulative impact, which strategies are the most technically or financially feasible, and which are least likely to hit political-economy obstacles to their implementation.

What is clear from the research is that there is no 'one size fits all' solution. Achievable objectives and 'low-hanging fruit' differ across countries, depending on political constraints, geography, natural-resource endowment, industrial structure, government institutions and more. The chapters within offer country-specific guidance on which approaches will work best towards establishing an effective climate strategy blueprint for the future.

However, it is also evident that policymakers in one country can learn from established and successful policies already in existence in other countries, and several common themes emerge which the authors suggest must be capitalised on, including reforming policies on carbon taxation and regulations on carbon emission; rethinking policies on the price mechanism and the elimination of energy subsidies; the use of retraining programmes aimed at increasing the supply of 'green' skills; increases in public investment in green infrastructure; and better information provision on the climate risk involved in respective technologies.

Time is running out in the global fight against climate change. This eBook contributes towards the growing discourse with comprehensive analysis and detailed appraisals on a range of practical and cost-effective policy actions that governments can implement in the short and long term to work towards attaining respective climate objectives.

CEPR is grateful to Francesco Caselli, Rick van der Ploeg and Alexander Ludwig for their expert editorship of this eBook. Our thanks also go to Anil Shamdasani for his skilled handling of its production.

CEPR, which takes no institutional positions on economic policy matters, is delighted to provide a platform for an exchange of views on this important topic.

Tessa Ogden
Chief Executive Officer, CEPR
October 2021

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Introduction

Francesco Caselli, Alexander Ludwig, and Rick van der Ploeg
London School of Economics and CEPR; Goethe University Frankfurt, ICIR and CEPR; Oxford University and CEPR

We are in the midst of a process of climate change, which is already wrecking severe damage to the livelihoods of billions around the globe. Together with adapting to the changes that have and will occur, slowing the rate of increase of average temperature, and limiting the level at which temperature will eventually settle is the defining challenge of our generation and the most important determinant of the prospects for prosperity of future ones. The target agreed on in the 2015 Paris United Nations Climate Change Agreement is to ensure that global mean warming stays below 2°C above pre-industrial levels and preferably limit the temperature increase to 1.5°C. This implies that emissions for the whole planet should be reduced as soon as possible and reach net zero in the second half of the 21st century – a drastic deceleration of the rate at which we currently release greenhouse gases (GHG).

The 6th Report of the Intergovernmental Panel on Climate Change, published in August 2021, confirms that human influence has warmed the atmosphere, oceans, and land, and that widespread, rapid, and often irreversible changes in the atmosphere, ocean, cryosphere, and biosphere have occurred in an unprecedented manner. Observed changes in extremes such as heatwaves, heavy precipitation, droughts, and tropical cyclones and in particular their attribution to human influence has strengthened since the 5th Report. Continued global warming will weaken the ability of oceans and forests to slow down the accumulation of carbon in the atmosphere. Hence, to ensure that the world's climate goals are met and that the world economy thus reaches net zero emissions of greenhouse gases (primarily CO_2 and methane) by mid-century, effective policies must be implemented.

As is clear even from the essays collected in this book, such policies are at least as numerous as the manifold sources of those emissions themselves. On the one hand, this is good news because it means that there are potentially many levers which can be activated to reach emission targets. On the other hand, it does challenge governments with limited bandwidth for decision making, consultation, or political persuasion to prioritise among the various options. Given the vital importance of urgent action, picking the right priorities could make the difference between success and failure.

The main aim of this book is to offer contributions to each of the featured nations' debates over the climate change policies to fast track. Which policies will have the fastest and/or largest cumulative impact? Which ones are the most technically or financially feasible? Which are least likely to hit prohibitive political-economy obstacles to their implementation? Since we felt that the answers to these questions were likely to be country-specific, we decided to commission (mostly) country-specific essays. As we now read the essays, we find our conjecture was correct: the low-hanging fruit are indeed different in different countries. What the 'no brainers' and low-hanging fruit in any country are depends on which climate policies are already in place and what the political constraints are, as well as the country's geography, natural-resource endowment, industrial structure, government institutions, and so on. This does not mean, however, that one country cannot learn from the debates taking place in another, or even occasionally identify similar low-hanging fruit – particularly when some countries are further behind in their fight against carbon emissions than others. Allowing at least some of the essays to double as case studies helpful to other countries is an ancillary goal of the book.

These dual objectives lie behind the strategy for country inclusion in the book. Obviously, it would have been impossible to have each country in the world, or even a majority thereof, represented. We therefore prioritised countries which are very large emitters in absolute terms, for the obvious reason that progress in abatement in these countries would have the maximum direct impact on climate change; countries which wield political influence on other countries, for example via their membership of political or economic unions; and countries which have been at the forefront of climate change policy and so can serve as case studies for others. Clearly, these are not mutually exclusive criteria. Admittedly, we have sometimes run into constraints in our access to expertise, so that not all countries we were hoping to include are represented. Nevertheless, the essays presented in this book cover most of the large emitters (or, in one case, group of emitters) and a wide range of experiences. In the rest of this introduction, we first present an overview of the individual country chapters, we then offer a brief summary of some additional chapters which tackle cross-country or international issues, and we conclude with further thoughts of our own about what we see as priorities which transcend the individual country experiences.

COUNTRY-BY-COUNTRY OVERVIEW

The elimination of energy subsidies is the main focus of Elisa Belfiori's chapter on Argentina. She acknowledges the regressive impact of the measure, which needs to be compensated through transfers to low-income families. This is particularly important in a country with such a high share of the population living in poverty. But she also stresses that, besides the obvious direct benefit in terms of reduced emissions, this policy would also indirectly alleviate its social costs by promoting innovation and technological progress, and thus economic development. In addition, the elimination of subsidies would improve the government's fiscal position, which is currently precarious. A natural second step would then be to implement carbon taxes. Additionally, given the large economic share of the Argentinian agricultural sector, climate policies must encourage the improvement of food quality, nutrition for cattle to increase productivity without additional harmful land use and fostering natural carbon sinks through soil management. Belfiori concludes by warning that, especially for a strongly outward-oriented economy like Argentina, robust climate policies are important to avoid the tariff and non-tariff barriers which future climate coalitions are likely to impose on countries with lacklustre abatement records. It is therefore a no brainer for Argentina to engage in climate change policies.

The chapter on Brazil by Clarissa Gandour and Juliano Asunção focuses on the low-hanging fruit in the Amazon. Clearly, the Amazon forests are crucial carbon sinks for the planet, and they contribute significantly to limiting global warming. It is therefore important that they remain intact. This chapter argues that Brazil has managed to cut Amazon deforestation between 2004 and 2012, thus leading to a drop in Brazilian carbon emissions of 1.5 Gt CO_2 equivalent (a 45% drop). Although nowadays most logging is illegal and Brazil is thus technically able to arrest Amazon deforestation, the problem is that this requires a political will which is currently lacking. A no brainer for Brazil is thus to make enforcement of environmental law independent of political control, to further improve information systems on illegal logging, and to target those areas that are most affected by illegal logging. Another no brainer is to invest in arresting forest degradation and in protecting forest regrowth.

Energy subsidies, which effectively subsidise the burning of fossil fuels, are the main focus of the chapter by Rabah Arezki, Rachel Yuting Fan, and Ha Nguyen on the Middle-East and North-Africa region. While their elimination is the clearest technical no brainer towards emission abatement in this area of the world, the authors warn that these subsidies are part of an implicit social contract – because at the moment they help a large fraction of the population living in poverty. Unlike other countries with well-developed tax and transfer systems, governments in this region are not currently equipped with the fiscal infrastructure to protect the poorest from the impact of the elimination of energy subsidies. For this reason, the authors argue in favour of an integral approach for the transformation of the economic system in the MENA region. Any reform of subsidies in the energy sector must be preceded by a reform of the government to provide reliable government services.

The chapter also confronts the fact that global climate goals can only be met if a large fraction of fossil fuel reserves is kept underground, which means that countries in the region will have to switch to renewable resources, accelerate the transformation of energy systems, and decarbonise transportation. Such exploiting of renewable resources would be doubly beneficial as it would reduce GHG emissions while at the same time preventing energy costs from rising. This transformation of the energy system will require large investments and countries in the region must therefore improve governance in the financial sector to attract funds from international investors.

The chapter on India by Shoibal Chakravarty and E. Somonathan focuses on coal, which accounts for a whopping 64% of India's CO_2 emissions in 2021. Since coal combustion also releases other deadly pollutants and particulates, its elimination would have collateral local environmental benefits. The current tax accounts for 20–40% of the price of coal paid by coal-burning power plants, which the authors consider to be well below the level which would internalise even the local component of the pollution externality. The authors recommend an immediate national ban on new coal plans (extending already-existing bans in several states) combined with a gradual increase in the tax on coal to choke off any expansion in the industrial use of coal released by the decline of the coal-based power-generating sector. Revenues from the tax should be used to facilitate the transition to other energy sources as well as to protect laid-off workers and consumers affected by increased prices. They should also be used to improve the reliability and affordability of electricity supply to households to discourage the use of residential cooking fires, an important emitter of black carbon.

Another no brainer is for India to mandate the electrification of two- and three-wheeled vehicle production by 2030. Two- and three-wheelers currently contribute 2% of India's CO_2 emissions, but the size of the fleet is expected to more than double over the next six years. Electrification would thus have a major impact on India's emissions. Once again, there are important co-benefits in terms of other pollutants and particulates. Furthermore, electrification of this sector would have important positive spillover effects in developing battery storage capacity and lowering the cost of electric vehicles in the passenger car, bus, and freight segments.

As the world's largest emitter, China is at the centre of global efforts to limit the severity of climate change. Both the chapter by ZhongXiang Zhang and the one by Martin Raiser and Sebastian Eckardt emphasise the enormity of the challenge represented by China's emission commitments, i.e. to go from peak emissions in or before 2030 to net zero in 2060. This challenge is the more daunting given the energy-intensive industrial composition of China's manufacturing sector. Indeed, both essays argue that structural change leading to a decline in the shares of industries such as power generation, iron and steel, and cement should be a key strategic target. Raiser and Eckardt caution, however, that such transformation could have highly asymmetric social and economic impacts in different regions of the country. As with the case of India, Zhang emphasises the phasing-out of coal-based power generation as this sector dominates power generation. Achieving this goal is tricky because of the relatively young age of much of the installed coal-fired capacity. However, a combination of selective closures of individual plants ripe for retirement, and an acceleration in the development of carbon-capture technology could be effective in helping this sector reversing the growth of its emissions.

Raiser and Eckardt advocate a re-orientation of Chinese climate policy towards a wider use of carbon pricing and economy-wide incentives rather than industry-specific policies such as quotas and targets and, more generally, regulatory intervention. In their view such a reorientation is needed to unleash market-based innovations in low-carbon technologies, without which current emission targets may be unreachable. Carbon pricing is seen as an essential pillar of this market-based approach, and both Raiser and Eckardt and Zhang advocate expansion of the national carbon trading schemes to industries other than power generation. For carbon pricing to be effective, however, total emissions and individual allowances need to be tightened, among other important reforms of the trading scheme discussed by Reiser and Eckardt, who point to the European scheme as a potentially good template. These reforms could be usefully complemented, according to Zhang, with complementary changes in the electricity market, such as the removal of electricity price controls so that power generators can pass higher carbon prices on to consumers to incentivise them to cut emissions – or at least the conferral of an electricity price premium to energy producers who implement carbon abatement technologies. Raiser and Eckardt also suggest that replacing "peak before 2030" with an explicit target and path for emissions throughout towards net zero could provide the carbon trading scheme with a stronger informational basis for efficient pricing, as well as having other benefits in terms of providing a policy anchor and a much-needed signal to enterprises and local governments.

In their chapter on Russia, George Safonov, Alexandra Dorina, and Julia Safonova identify a wide range of low-cost policies with a huge mitigation potential for the Russian economy, which is the fourth-largest emitter in the world. First and foremost, many actions are required in the crucial area of energy efficiency. These are helpfully divided into low-, medium-, and high-cost categories, but they are all technically feasible and would have a massive impact, given the state of Russia's industrial, residential, and transportation capital stock. Second, the government needs to favour a transition to renewable energy sources, primarily via the reshaping of the regulatory framework to make it less hostile to investment in renewables and less friendly to fossil fuel lobbies. The chapter also discusses ways in which the Russian economy can position itself as a global supplier of low- or zero-carbon energy sources, such as hydrogen or biofuels, whose development is again currently impeded by a hostile regulatory framework. Russia also needs to implement and/or improve the enforcement of a variety of regulations which will reduce methane emissions from gas pipelines, coal mines, and landfills, particularly as the technologies required are all low-cost ones. Innovations currently afoot also have the potential to reduce NO_2 emissions. In the medium term, technological change and experimentation with carbon capture technology present important opportunities.

Given Russia's enormous landmass, and the global demand for carbon offsets, the country has an immense potential to remove carbon in forests via forest protection, forest management, forest planting, and soil protection via forest belts. A forest-based strategy would be complementary to incentives to substitute carbon-intensive materials in the construction and industrial sectors with wood and other plant-based substances. There is vast potential for emission mitigation in agriculture as well, for example via the widespread diffusion of no-till farming. Clearly, identification of all this low-hanging fruit will be of little benefit if the Russian government does not adopt much more ambitious targets for emission reduction than those currently in place.

The chapter on Australia by Frank Jotzo and Warwick McKibbin first points out that a strengthening of ambitions on climate change is highly desirable to make Australia's prospective contribution comparable to that of other nations. They identify the current absence of a long-term national strategy on emissions reduction as a significant impediment to guiding both policy and private investment decisions. Nevertheless, they identify several policy ideas that could sustain a more meaningful participation of the country in the global emissions-reduction effort, which currently are almost entirely market driven, with only a few, largely ineffective, public policies in place. A key proposal is to achieve economy-wide carbon pricing through the creation of an emissions trading scheme with tight baselines. This can be achieved relatively easily by modifying and extending the current safeguarding mechanisms.

Just as in India and China, another critical objective is to expedite the transition of electricity generation from coal (which still accounts for 60% of the power produced) to renewables (for which Australia's potential is enormous). This is happening through market mechanisms, but to achieve the meaningful acceleration that is needed requires large public investments in new wind and solar generation assets, transmission infrastructure, and energy storage. Jotzo and McKibbin usefully sketch the types of adjustment funding which could help overcome political resistance to these policies, particularly in communities where a large percentage of jobs still depend on coal, though they also point out that large infrastructural investment in renewable production, transmission, and storage will by themselves contribute to cushion some of those communities' losses. High returns from government intervention also exist in the R&D and technology-adoption area, where a combination of subsidies and tighter regulation could, for example, accelerate the diffusion of electric vehicles or enhance the energy efficiency of buildings.

As with many other chapters in this book, the chapter on the United States by Lint Barrage emphasises the importance of the role played by the political process, as exemplified by the shift in attention towards climate policies in the United States with the arrival of the Biden administration. Barrage stresses as a key no brainer the importance of a national carbon price that needs to be set at an appropriate level. It would entail relatively small gross costs – because the revenue created can be redistributed to compensate households – and large environmental benefits thereby creating large net benefits for the economy. A further no brainer according to Barrage are technology subsidies and public funding directed towards green activities. The US economy is in a unique position as a world-leading country to develop decarbonisation technologies and to thereby directly address R&D and network externalities in the industrial sector. Finally, the chapter notes that information for investors through climate risk disclosures plays a key role in combatting climate change in a market economy. Such information provision would efficiently allocate funds towards advanced technologies and 'sustainable' assets.

The need for a nationwide carbon tax also plays a prominent role in the chapter on Canada by Carolyn Fischer and Dave Sawyer, who note that a low-hanging fruit of Canadian climate policy is better coordination of the patchwork of carbon price programmes that already exist in the country. Hence, they offer detailed suggestions on how to integrate programmes at the levels of the federal governments, the provinces, and the territories, and to develop and apply a common standard of coverage for emissions across carbon pricing systems. Furthermore, the authors advocate the elimination of carbon price rebates tied to fuel purchases. While these rebates reduce the financial impact of carbon prices on households and businesses, distributional concerns should be addressed through the income tax system and the price signal should not be distorted by such rebates. Furthermore, carbon pricing policies will have to become more stringent in the emissions-intensive and trade-exposed heavy industry of the country, including the oil and gas sector. This also includes adding ratcheting down factors into the emission intensity benchmarks to reflect the transitional issues of these benchmarks, namely, allowing firms the time to transition to lower emitter operations.

Just as argued for the two Northern American countries, in their chapter on the United Kingdom, Sam Fankhauser and Simon Dietz point out that the existing system of carbon pricing requires reform. The current UK policy mix through different taxes, subsidies and regulation creates uneven incentives to cut emissions. These schemes make building renovation and the switch from gas boilers to electric heat pumps much less attractive. The chapter also highlights the need to promote zero-carbon finance. While the chapter on the United States emphasises the importance of information in this context, the chapter on the United Kingdom stresses the relevance of time-consistent and reliable government policies. Furthermore, Fankhauser and Dietz turn to an important element to dampen the potentially adverse labour market impacts of climate change by arguing that the workforce needs training programmes to adopt to a zero-carbon environment. This would smooth the transition towards carbon-free production processes for workers. Common themes in the North American countries and the United Kingdom are thus to reform the price system and to support green capital market investments via incentives and time-consistent government policies.

Christian Gollier argues in his chapter on France that, due to its investments in novel nuclear power plants before 1990, the country has already plucked the lowest-hanging fruit of its climate policy. Since wind and solar power would mostly substitute for nuclear, any policies directed towards such alternative energies would have few short-run effects on carbon emissions. While it is important to electrify the transportation sector, this will be costly. And as Gollier further argues, the vivid 'yellow vest' movement in France clearly shows that social acceptability of climate change measures requires attaining any objective at the lowest costs possible for the economy. With this in mind, he concludes that a more promising policy is the conversion of domestic heating from fuel oil to heat pumps, which could be incentivised by integrating the residential sector into the EU Emissions Trading Scheme.

In their chapter on Germany, Simon Black, Ruo Chen, Aiko Mineshima, and Ian Parry argue that to efficiently achieve its targets on emission reductions, the country requires harmonised carbon pricing. Adverse distributional consequences of carbon prices should be addressed through transfers to low-income households, which can be achieved by reducing their social security contributions. Concerns of carbon leakage – i.e. the shifting of carbon-intensive production from 'cleaner' to 'dirtier' countries – should be addressed through trade deals with major trading partners. A second no brainer would be the introduction of feebates (discussed in detail in another chapter of this book), particularly on vehicle manufacturers, which would be an efficient approach to reduce emissions in the German transportation sector. The chapter further argues for public investments to address network externalities associated with a clean technology infrastructure and subsidies for R&D on green technologies. These subsidies can be phased out gradually over time because of economies of scale and cost degression.

In an additional chapter on Germany, Claudia Kempfert is critical of existing policies and the modesty of targets. The now completed and highly controversial Nord Stream II natural gas pipeline and the commissioning a new coal-fired power plant in North Rhine-Westphalia are cited as examples of stranded assets. Kempfert argues that no brainers are to speed up the phase out of coal, to decarbonise the transport sector more quickly, to expand the network of charging stations for electrical vehicles, and to get rid of environmentally harmful subsidies (e.g. for diesel). She further argues that redistribution measures have often been regressive and argues for mobility allowances independent of the individual tax rate instead of the current commuter allowance. In terms of targets, she argues that Germany needs to make its emission strategy consistent with those underlying the Paris agreements, a task which might be encouraged by the more ambitious goals formulated in the European Green Deal (discussed in detail in another chapter of the book). It also helps that Europe wants to extend emissions trading to the building and transport sectors.

With an already-impressive record of emissions abatement and one of the most ambitious sets of emissions reduction targets in the world (including a 70% reduction relative to 1990 by 2030), **Denmark** is an excellent example of how relatively low-hanging fruit can still be found in countries at the forefront of the emissions reduction effort. Peter Sørensen's leading proposals include the conversion of organogenic soils from agricultural use into wetlands and other measures to reduce emissions from the agricultural sector. There are also significant gains available from facilitating the electrification of the transportation sector, for which technology is already available. Somewhat more dependent on technological development, but still highly realistic, is the deployment of technologies for carbon capture and storage in various power-generating and industrial processes. A more speculative proposal, but with high emissions-reduction potential, is the application of pyrolysis to biomass waste. These policies, which require individual and specific pieces of taxation, subsidisation, and regulation, should be complemented by a comprehensive emission tax, covering all greenhouse gases (not just CO_2), whose implementation and ancillary benefits Sørensen outlines clearly.

Last but not least, Sørensen points out that a country which is at the forefront of the effort to reduce domestically *produced* emissions can and should turn its attention to broadening the focus of climate change to include *consumption-based* emissions targets instead of focusing exclusively on production-based targets, as illustrated by the example of imported biomass of electricity generation. He outlines how even a country with considerable constraints on its tariff policy, like Denmark, can still use combinations of production subsidies and consumption taxes to minimise carbon leakage. Denmark has already decided to prohibit extraction of oil and gas by 2059 at the latest. It also is an example of how a well-functioning network of interconnectors (particularly with hydropower from Norway and Sweden) can solve the security of supply from intermittent sources.

The chapter on Norway by Michael Hoel focuses on the country's policy of ensuring that all cars will be electric by 2025. Although Norway's costly policy of boosting electrical cars has cut emissions, it is not clear that this has reduced global emissions. One no brainer that emerges from this chapter is that Norway's tax system should be reformed, since it currently encourages investments in the gas and oil sector that may not be socially profitable. Furthermore, stopping non-profitable petroleum investments will also reduce global emissions.

The chapter on Sweden by John Hassler highlights the difficulties in achieving fast emissions reductions in transport due to the high abatement costs in this sector, and that consequently the energy transition may be quite costly. This chapter also suggests that the cost of cutting emissions by one tonne of CO2 varies a lot by sector and by policy measure. So, this might suggest that there is low-hanging fruit in equalising these costs per tonne of CO_2. The chapter also indicates that it is a no brainer to stop subsidising burning wood, which is bad for the climate and bad for health, and to foster sequestration of carbon. All in all, Hassler argues that from the point of view of cutting emissions in a cost-effective manner, it is better to focus on sequestration and forests than on transport.

The same paucity of ambition is lamented by Karolina Safarzynska in her chapter on Poland, where low-hanging fruit is identified in the rejuvenation of the vehicle fleet via fuel-efficiency requirements, a ban on imports of old cars, scrapping incentives, and other transportation policies. They are also identified in the elimination of coal as a source of domestic heating, particularly in domestic boilers, where the current incentive systems need to be redesigned and better 'sold' to consumers, coupled with improved insulation. The scrapping of regulation hostile to wind turbines and the clarification of legislation regulating micro-renewable generators could also have immediate and measurable benefits.

Finally, while we have emphasised the identification of policies that could be adopted relatively quickly at the country level, there is clearly enormous potential benefit in supra-national policymaking and coordination. This is well illustrated in the chapter by Phoebe Koundouri et al. on the European Green Deal, which was capitalised by the members of the European Union in 2019 and is integrated within the UN-sponsored Agenda 2030 for Sustainable Development.[1] The chapter is a useful exercise in reconciling goals and programmes across multiple supra-national policy initiatives; it outlines policies for

1 We include the chapter on the European Union as part of our country-by-country overview because of the joint governance structure at the level of the European Union. In this respect, the European Union shares similarities with the United States and other large world areas.

European-led technological development in the climate area and institutional innovation towards green finance and (as in several of the other chapters) pays careful attention to the distributional consequences of climate mitigation policies.

SOME INTERNATIONAL AND OTHER ISSUES

While the country chapters represent the core of the book, we have also invited a few contributions on themes that apply to international transactions or cut across individual countries.

As we have learned from the country studies, in many countries carbon taxation is politically difficult due to its impact on energy prices and the resulting burden on households and firms, and it is not always easy to rebate some of the carbon tax revenue to repair the adverse distributional consequences. Ian Perry argues that, in these cases, feebates may represent a useful second-best alternative. The idea behind feebates is to implement revenue-neutral sliding scales of fees or rebates on products or activities that are above, and respectively below, average emissions intensities. This reinforces mitigation at the sectoral level without directly impacting energy prices to the same extent that wholescale carbon pricing would. Feebates can be applied to sectors such as road transport, power generation, buildings, industry, forests, agriculture, and international maritime commerce.

Another strategy is to shift the cost of current abatements to future generations or consumers in rich countries, as proposed by Laurence Kotlikoff, Felix Kuber, Andrey Polbin, and Simon Scheidegger. This requires combining a global carbon tax with substantial net transfers from future to current generations (achieved by running up a government debt), and from rich or less carbon-intensive countries to poor or more carbon-intensive countries. The idea that current generations *must* make sacrifices for future generations and that carbon-dependent countries *must* make sacrifices for less heavily carbon-dependent countries is thus misleading. Indeed, the authors argue that their proposal is a Pareto improvement for all generations in all countries.

Since universal carbon pricing is probably not entirely realistic in the short run, countries which price carbon might choose to build a 'climate wall' vis-à-vis countries which do not. Luis Garicano and Maria Fayos Herrera advance various pragmatic proposals on the implementation of a carbon border adjustment mechanism (CBAM) on the carbon content of imports. This will avoid carbon leakage. Garicano and Herrera show how the carbon content embedded in imported products could be computed in the same manner as is currently done for produced goods under the European Emissions Trading Scheme, the world's largest cap-and-trade carbon market. The indirect emissions arising from electricity consumption should also fall under the CBAM. Clearly, such a CBAM encourages trading partners to decarbonise too. It can also be viewed as the entry ticket to a 'Climate Club', where members incur cost of climate abatement through carbon pricing while non-members contribute through the 'fees' they pay to the club. The idea is that this sets in motion a virtual spiral where more and more countries price carbon.

FURTHER AND FINAL THOUGHTS

We hope that the preceding pages give relatively accurate and informative guidance to readers as to where to find the information they need in the individual chapters. We conclude this introduction with a few additional (and selective) thoughts of our own on climate policy priorities (to the limited extent that generalisations beyond the country-specific setting are possible). These observations are often motivated by what we have learned from the chapters in the book, but in some cases we draw on separate reflections.

Recent research calculates that to keep global warming below 1.5°C relative to pre-industrial levels with a 50% chance, it is necessary to keep globally 89% of coal reserves and about 60% of oil and gas reserves in the ground (Welsby et al. 2021). The simplest and most direct way to achieve this is to mandate the phasing-out of all fossil fuel extraction. This may seem a political nonstarter, but in fact we have seen that it is already a policy reality in Denmark, and it is at least on the table in Norway (where it would have a large global impact). Note that even if only some significant producers did this, besides the obvious direct effect there would also be an indirect effect through the price of fossil fuels, encouraging decarbonisation in other countries as well.

Prohibiting fossil fuel extraction essentially sets the price of carbon to infinity. There are many other, less radical policies which attempt to simply increase the price. First, subsidies for fossil fuel or carbon-intensive economic activities should be ended as soon as possible, at least in those countries where the government has access to an income tax and/or subsidy system which allows it to credibly repair any adverse consequences on lower-income citizens (for example, due to higher electricity prices). Second, carbon should be priced as uniformly as possible for each country and each sector to internalise the global warming externalities resulting from emissions. A robust initial carbon price that rises credibly, steadily, and predictably over the next 30 years and at a pace compatible with the target of net zero emissions by 2050 will give a clear signal to energy producers and to industry to move into renewable energies. The carbon pricing can be implemented via broad cap-and-trade emission markets, carbon taxes, or some of the other schemes exemplified in the chapters of this book.

While carbon must be made more expensive, it is also important to subsidise renewable energy production to internalise *learning-by-doing* externalities. Likewise, it is key to subsidise green innovations to kick-start technical progress towards a green economy and to internalise green R&D externalities. It is thus crucial for a successful green transition to make it cheaper for industry and households to make the move. This is likely to be popular and to lead to less political obstacles than carbon pricing.

Subsidies and public investment also play an essential role in overcoming any *chicken-and-egg* or *network* externalities to set flywheel effects in the adoption of green technologies in motion. For example, a boost to charger stations in cities might lead to a boost in electrical vehicles, which in turn will lead to more demand for charger stations and bigger production runs and drops in the cost of electrical vehicles. This in turn will lead to further increases in demand for electrical vehicles and charging stations, and thus lead to a virtuous circle. These R&D and network externalities also occur in the power generation sector and feature in the chapters on the United States and Germany. To internalise these positive network externalities, green public and private investment programmes may be required.

Last but not least, in many countries there is incredibly low-lying fruit in sequestration via forestry and agriculture. Tree planting and climate-friendly agricultural innovation could play an enormous role at very low cost (or even perhaps at negative cost) in the fight against climate change. Illustrations of this crucial principle abound throughout the chapters in this book.

SUMMING UP

There is now a strong sense of urgency to get to net zero emissions in the next three decades, not only to limit global warming but also to reap the collateral local benefits of cleaner air and better health. Although various policies such as getting rid of fossil fuel subsidies, stopping coal production, carbon pricing including carbon tax adjustments, transfers to ensure political acceptability, and green investments are common to all countries, many of the no brainers and low-hanging fruit in climate policy depend on the specific characteristics of individual countries. We hope that the detailed appraisals found in the chapters of this book will inspire policymakers. Two things are clear: the arsenal of policies that can be called upon to achieve net zero emissions is rich and varied, and any delay in implementing these will invariably lead to much higher costs.

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CHAPTER 1

No brainers in Argentina's climate policy

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THE AGGREGATE PICTURE

Overall emissions in Argentina add up to 364.44 $MtCO_2e$, according to the latest biennial update report submitted to the United Nations Framework Convention on Climate Change. Total emissions have remained more or less stable over the years, with a gradual downturn since 2007. The latest estimation corresponds to the year 2016 (SGAyDS 2019).

Emissions come primarily from energy use and livestock. Argentina's energy matrix relies heavily on natural gas, and agriculture and livestock lie at the centre of its economic activity. While energy use explains the most significant national contributions, emissions from livestock are mostly methane – a gas with higher warming potential.

Thus, an instrumental national climate policy must target these two economic sectors.

Importantly, Argentina is a country of high inequality – with more than 40% of its population living in poverty. It is also a country subject to regular economic turmoil and a history of recent government default experiences. Designing a national climate plan is difficult when only half of the population could face its cost and when other priorities and financial crises arise regularly. Including distributive policies in the country's climate plan emerges as an essential component.

Searching for no brainers and low-hanging fruit in Argentina's climate policy requires a comprehensive approach that looks at the aggregate picture.

It is even fair to question whether there is a no brainer climate policy, given the complex environment. Argentina contributes to 0.7% of global emissions. The impact of its climate policy is low on the global scale, but its climate policy can lead to unpopular costs and unwanted redistributive effects on a local scale. Moreover, Argentina has arguably not contributed much to the existing stock of carbon dioxide in the atmosphere. These are some of the common arguments posed against Argentina's acting on climate policy.

It is imperative to state these concerns upfront and convince the reader that the first absolute no brainer for Argentina is to actually engage in climate policy. Argentina is rich in natural resources, and its economy depends on their exploitation. Soy, maize, and meat exports are central to the economy. As is well known, these activities are highly vulnerable to climate change. Thus, it is in Argentina's interest to fight climate change in an internationally coordinated framework.

However, confronting climate change is probably not the only reason for engaging in climate policy. Argentina benefits from being an active player in international markets. With a troubled history of government defaults on the national debt, the country knows at first hand the costs of closing the economy and being excluded from international markets. As countries around the globe join efforts to fight climate change, climate coalitions or clubs are likely to form (Nordhaus 2015). Countries that do not cooperate in this fight will face punishment through tariffs and non-tariff barriers. Not engaging in climate policy will eventually become comparable to defaulting on the national debt, leading to similar costs and consequences.

Overall, despite valid concerns about the country's weak economic conditions, the critical no brainer for Argentina – while not a low-hanging fruit – is actively engaging in climate policy. In the next section, Table 1 presents a list of other no brainer climate policies for the country, together with a comment about the cost-effectiveness, the political feasibility, and the challenges associated with implementing each policy.

AGRICULTURE AND LIVESTOCK

The agriculture and cattle-ranching sector offers excellent potential for Argentina to reduce its emissions and shape its climate policy strategy. The sector contributes to climate change due to its emissions but is also highly vulnerable to it. Also, the sector is tightly linked to international markets, where it plays an active role as a commodities exporter. Facing the risk of possible future trade penalties from countries organised into climate coalitions, it is in the interest of farmers and landowners to welcome practices to control the sector's emissions and transform its production into sustainable export goods.

The primary sources of emissions, ranked in order of importance, are methane (CH_4) emissions from ruminants, carbon dioxide (CO_2) from deforestation, and nitrous oxide (N_2O) from fertilizers and animal urine. The volumes emitted of N_2O and CH_4 are lower than those of CO_2, but they have higher warming potential. The warming potential of methane is about 30 times that of carbon dioxide over 100 years, and that of nitrous oxide is about 300 more.

A nontrivial aspect of climate policies affecting agriculture and livestock is that they must align with the growing demand for agricultural products and meat that the growth in the global population brings. An expansion of cultivated land cannot be the basis for this growth. Such an expansion would lead to biodiversity loss, greenhouse gas emissions, and land degradation – worsening the climate problem.

The challenge is to design policies that restrict emissions while simultaneously allowing for a production increase. Natural candidates are policies that focus on emissions intensity (i.e. producing the same while releasing fewer emissions) and boost productivity.

Emissions from cows' enteric fermentation contribute the most to the sector's overall emissions. Hence, they are also where the most critical emissions savings lie. This is mainly because the activity offers a dual tool to control emissions: direct mitigation through decreased emissions from cows, and emissions capture through good practices in land use.

Feed quality, good nutrition, and matching ruminant production to the underlying pastures help reduce cows' emissions. Other policies to reduce emissions from ruminants relate to reproduction rates, animals' overall health, and breeding management practices (Gerber 2013, FAO and NZAGRC 2017).

These are relatively low-cost policies that could also boost productivity. Therefore, they are good candidates for no brainer sustainable practices for producers. Some of these policies are already in place. However, they should become common practice as producers gain awareness of their benefits and of the potential penalties that those who continue with old non-sustainable practices could face in international markets.

Researchers and technicians from the Instituto Nacional de Tecnología Agropecuaria (INTA), a public research institution in the Ministry of Agriculture, Livestock, and Fisheries of Argentina, are actively working on measuring and reducing the sector's emissions. A popular project was named 'the backpacking cow' because it captured methane from cattle in backpacks attached to cows. The idea was to transform the methane into biofuel and reuse it for energy generation. The project did not succeed. Instead, research now focuses on measuring cow emissions and their characteristics based on geographic areas and animal nutrition. The goal is to produce meat and milk more efficiently (Ricci et al. 2018).

Taking advantage of the underlying pasture and soil to capture carbon is an excellent complement to these practices (Andrade 2017). No-till farming – a technique broadly adopted by Argentinian farmers – is an example of this. This type of farming avoids tillage and covers the soil with crop residuals, preserving the quality of the land and minimising soil erosion. The system improves crops yield while at the same time maximising soil carbon capture. It is another win-win policy recommendation.

TABLE 1 ARGENTINA'S TOP FIVE NO BRAINER CLIMATE POLICIES

	Top five Argentina's no brainer climate policies	Cost-effectiveness	Political feasibility	Challenges
1	Embrace and actively engage in climate policy	Low cost; it should be a no brainer	Medium; the country regularly loses itself in short-run crises	Sort out the political arena
2	Improvements in feed and quality nutrition for cows, complemented with good practices in soil management to act as a carbon sink	Low cost	Easy; farmers must learn their benefits from doing this.	Establish a mechanism to account for carbon capture in soil
3	Protect and develop carbon sinks in the land, natural forest, and soil	Medium cost; it implies giving up rents in agriculture in the short run	Medium cost; implies negotiations with farmers and local communities	Enforce National Forests Law
4	Eliminate energy subsidies	Low cost, especially if fiscal costs are considered together with their macro consequences	Difficult; there is a long history and ideological pushes around the subsidies	Define a proper compensation mechanism
5	Increase carbon tax, and include natural gas	Low cost, especially accounting for fiscal and environmental benefits.	Difficult; the country is highly reliant on natural gas.	Define a proper compensation mechanism

A well-established mechanism to account for soil carbon capture is a vital requisite on a global institutional level. Such a mechanism is crucial to allow farmers to be accountable for their exact footprint (i.e. their cows' emissions net of soil carbon capture).

Argentina is a country with a vast territory and great potential to be a global source of carbon capture through land and trees. However, one side effect of agriculture and cattle-ranching is the associated deforestation . About one-third of the sector's emissions come from deforestation to turn the land into cropland or pasture for agricultural use.

Argentina enacted a National Forest Law in 2007, which is a step in the right direction. This law regulates land use to promote a long-term and sustainable use of native forests. As illegal logging has continued, however, it is necessary to refine the law and find mechanisms to enforce it. The mechanism mentioned above to account for the carbon captured through national forests, grass, and soil is also essential to this end. It will help create the right incentives to protect the land, linking this protection to its benefits.

Other possible measures for mitigating climate change in the agricultural sector are soil quality preservation through no-tillage techniques and compost coverage, biotechnology, more efficient use of inputs (including energy and water use), minimal fertilizers, and integral pest control. A combination of all these practices may be desirable and would not exclude one another.

The no brainers highlighted in this chapter are seen as having more significant potential to generate impact due to their contribution to the country's aggregate emissions balance. They are regarded as no brainers because they align with the incentives of private farms – the practices improve the sector's productivity by making more efficient use of the land and of resources, and they also reduce emissions.

As a final note, it is important to recall that the agriculture and livestock sector in Argentina is also affected by climate change in a wide variety of ways. Argentina must simultaneously adopt mitigation policies to reduce emissions and make adaptation investments to protect the sector and its crops adequately. Developing seeds that are resilient to temperature fluctuations and water shortages is an example of this.

Argentina is a world leader and an active player in the international markets for soy and maize commodities and meat. Research and technological innovation in agricultural production in the country is vibrant and spills over to the rest of the world. Working closely with the sector to make progress in the country's climate plan should be a no brainer national strategy. It is advantageous that the industry is world class, embraces change, and has historically endured multiple local and global challenges with innate creativity and passion. The chances of promising results are high.

ENERGY

Emissions from burning fossil fuels represent about half of Argentina's total emissions. The country is highly dependent on natural gas, the primary energy source for residential houses and manufacturing buildings. Oil and gas consumption for public transportation and cars is another substantial source of emissions.

Argentina is also naturally rich in these resources, with abundant oil, gas, and carbon reserves. Nevertheless, the energy supply is not always sufficient to meet demand. Argentina fluctuates between its own production and periods of relying on gas imports. At the same time, it is a country with vast potential for renewable energy generation, with strong winds in the south and much solar intensity in the north.

The current energy matrix comprises approximately 88% fossil fuels, 4% renewables, and 8% others, including nuclear and hydroelectric power. It is hard to envisage a carbon-neutral energy matrix in a relatively short period, given this framework. There are, however, some clear steps forward.

The most visible one has to do with energy subsidies. Argentina has a long history of subsidising energy. This has become a heavy fiscal burden – subsidies currently add up to about 1.4% of GDP. Importantly, this history contradicts the promotion of renewable power that the government is also attempting to foster. This contradiction is not particular to Argentina; it is present in many countries around the globe.

What is particular to Argentina, however, is how problematic the fiscal burden of energy subsidies is considering the country's high inflation, recent government debt default, and significant fiscal deficit. In this context, it is in the country's interest to engage in a sound energy policy for economic reasons, even without taking into account environmental considerations.

A sound energy policy must include getting rid of energy subsidies. Doing so will promote innovation and technological progress. Companies, investors, consumers, and stakeholders should be the leading engine of this process and the primary funding source of the infrastructure required for an efficient energy market.

The elimination of energy subsidies may not lead to a cleaner energy matrix in itself. It is difficult to transition to a carbon-free energy provision starting from an energy matrix that is lacking structure and technological advancements and is strongly reliant on natural gas. However, removing energy subsidies is undoubtedly the first step – perhaps the only no brainer one can uncover at the complex intersection of energy and climate policy in Argentina.

The regressive impact of this policy recommendation makes its implementation difficult and puts into doubt its feasibility (Giuliano et al. 2020). However, it is essential to disentangle the efficiency and equity sides of the problem. Economic policy should seek efficiency in the economy, understanding that this guarantees maximum societal welfare.

When the efficient solution brings unwanted redistributive effects, governments rely on transfers to undo them. It is thus vital to find mechanisms to compensate the households most affected by the elimination of energy subsidies. In this respect, lump-sum transfers to low-income families are better than the existing 'social tariff', which applies to the energy price because they minimise distortions (Urbiztondo et al. 2020).

A natural second step in Argentina's climate policy regarding the energy sector is to advance the development of the carbon tax on CO_2 emissions. The country introduced a carbon tax in the last comprehensive fiscal reform that took place in 2017. The tax turned the existing fuel taxes into a tax on the emissions linked to those fuels.

Although effectively a relabelling of tax rates, the implementation of the carbon tax was a crucial step in the right direction. It is a cause for optimism that the right policy instrument already exists in the national tax code; it is often politically easier to recalibrate a current tax rate than to introduce a new tax.

The most immediate advancement should be to include emissions from natural gas in the tax base. Natural gas emissions were part of the initial carbon tax proposal but were disregarded in its final version. The technical conversions from existing fuel taxes on gas to its CO_2 equivalents were also in the initial proposal. Thus, the technical details are ready, and the carbon tax on natural gas now just requires political will.

The previous qualification regarding the regressive nature of this policy recommendation also goes for the case of a tax on natural gas. Gas is the primary source of energy and heating in most Argentinean houses. A tax on it would have a heavy impact on vulnerable households. While the regressive nature of a carbon tax is a worldwide concern, it is particularly relevant for Argentina, where about half of the population lives in vulnerable conditions.

A compensation mechanism must be an essential element in any energy-related tax reform – eliminating energy subsidies and increasing carbon taxes.

Furthermore, the carbon tax rate should gradually align to the actual social cost of carbon. The initial proposal involved a tax of US$25 per tonne of CO_2 equivalent (CO_2e), but its final version implemented a much lower tax of $10.

Efficient prices in the energy sector will spill over to the transportation sector, which currently accounts for about 14% of overall emissions. The country covers a vast area with an extensive national road system and great demand for passenger and freight transportation. Also, there is a high concentration of buses, private cars, and railways in Buenos Aires and suburban areas, where one-third of the population live and work.

With the elimination of energy subsidies and a carbon tax, energy prices would adjust to reflect the actual cost of gasoline, and emissions from the transportation system wou fall too. The government must accompany these changes by fostering a change in passenger transportation modes, especially electric vehicles in public transportation and non-motorised alternatives in the big cities.

DEVELOPING COUNTRIES: ADAPTATION OR MITIGATION?

Developing countries face a complex combination of poverty, economic instability, social unrest, and income inequality. Resources are particularly scarce for these countries, and alternative investments and developing paths offer critical trade-offs. It is tempting to believe that the central climate policy no brainer for developing countries is adaptation. Chisari et al. (2013) find that the optimal policy, if it exists, for small countries would centre on climate adaptation (where 'small' refers to the country's emissions relative to the rest of the world).

The old classic argument is that developed countries — the main historical contributors to accumulated emissions and climate change — must lead the climate solution and reduce emissions. However, developing countries like Argentina face the looming threat of being isolated from international markets if they refuse to contribute to climate mitigation. Investments and technological innovations take time, and it would be risky to delay their implementation. These trade penalties are absent in the work of Chisari et al. (2013).

More importantly, confronting climate change is most likely not the main reason for implementing climate policy in developing countries. Instead, the no brainer policies discussed in this chapter reveal that most climate solutions involve finding better ways to do what is already being done. These better ways come from promoting competition and innovation and fostering international integration.

This chapter presents some obvious first steps for Argentina, most of which are also applicable to other developing countries and the Latin American region in particular.

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CHAPTER 2

Low-hanging fruit in the Amazon: Feasible and cost-effective paths for Brazilian climate policy

Clarissa Gandour and Juliano Assunção
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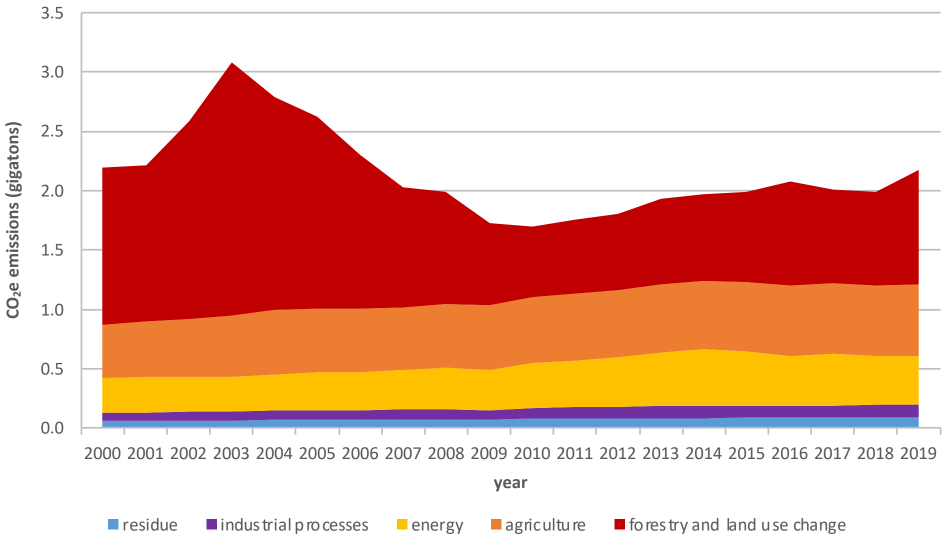
The loss of native vegetation in tropical ecosystems matters for greenhouse gas (GHG) emissions at the global level. Because tropical forests absorb and store enormous amounts of carbon, forest degradation and deforestation are significant sources of GHGs, particularly carbon dioxide (Pan et al. 2011, Brienen et al. 2015). Between 2007 and 2016, the agriculture, forestry, and other land use sector accounted for an estimated one-quarter of total global net anthropogenic GHG emissions, with deforestation responsible for most of the 5.2 ± 2.6 gigatons of annual net carbon dioxide emissions from land and land use change (IPCC 2019).

The Amazon is the world's largest tropical forest, and nearly 60% of it is in Brazil. Thus, Brazil plays a prominent role in the global effort to mitigate GHG emissions. Forestry and land use change accounted for half of the country's gross emissions over the last two decades; agriculture comes a distant second at 25%, and energy follows at 17% (Figure 1). Extending over an area nearly half the size of continental Europe, the Brazilian Amazon Forest is a vital carbon sink — and one that is rapidly being depleted. GHG emissions from the Brazilian forestry and land use change sector are largely due to the loss of tropical vegetation to deforestation, with the nine states that share the Brazilian Amazon Forest contributing with almost 85% of this sector's total emissions since the year 2000.

Protecting native vegetation in the Amazon is a feasible, cost-effective, and obvious way for Brazil to mitigate its GHG emissions. It has, in fact, done so before. The steep reduction in Amazon deforestation observed from 2004 through 2012 (Figure 2), when the annual rate of forest clearing fell by more than 80%, was the driving force behind Brazil's 45% drop in total emissions — nearly 1.5 gigatons — during this period. These were the largest sustained reductions in Amazon deforestation and GHG emissions the country has ever achieved. Since 2012, however, Brazilian emissions from the forestry and land use change sector have increased by more than 50%.

FIGURE 1 GHG EMISSIONS BY SECTOR IN BRAZIL, 2000-2019

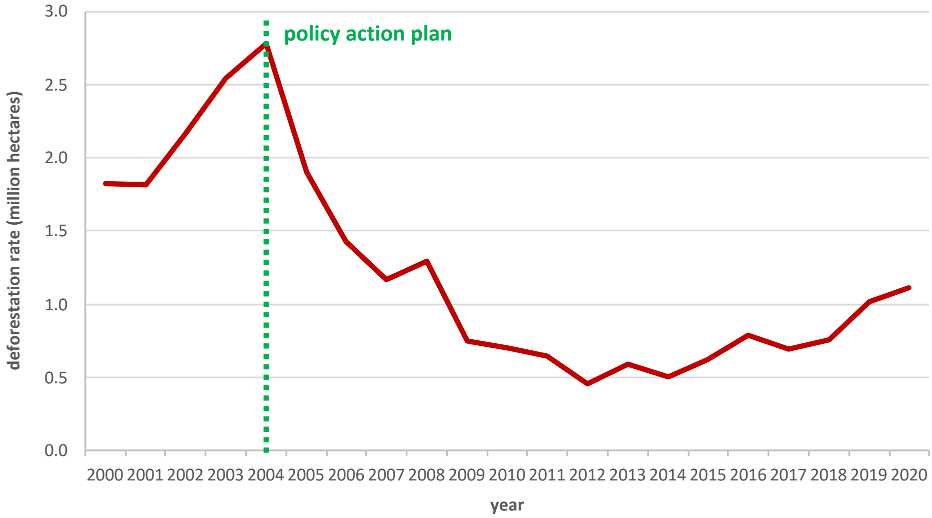


Notes: The forestry and land use change sector accounts for a large share of Brazil's total GHG emissions over the past two decades. The steep reduction in Amazon deforestation observed from 2004 through 2012 was the driving force behind Brazil's sustained decrease in total emissions during this period. Estimates cover all emissions sources included in Brazil's official National GHG Inventory. Carbon equivalent values refer to gross GHG emissions converted using GWP-AR5.

Source: Data from SEEG (2020).

Public policy played a crucial role in the Amazon deforestation slowdown. In 2004, at a time when Brazil cleared more tropical forest than any other country in both absolute and relative terms (Hansen et al. 2008), the Brazilian federal government enacted a policy action plan aimed at combating Amazon deforestation. The plan introduced a novel approach for forest conservation. It was pioneering in content and format, proposing several innovative strategic measures and coordinating them in an as-of-yet unforeseen inter-ministerial design for policy planning and implementation. The cornerstone of the action plan was the development of a satellite-based monitoring system to identify forest clearing hotspots and enhance the targeting of environmental law enforcement operations. These efforts were complemented by other policy initiatives. Within a decade, Amazon deforestation plummeted from more than 2.7 million hectares to about 500,000 hectares per year. Beyond the striking visual correlation (Figure 2), evidence supports the action plan's significant contribution to the Amazon deforestation slowdown (Assunção et al. 2015, Burgess et al. 2019). The strengthening of environmental monitoring and law enforcement — notably, the increased probability of catching environmental offenders due to the novel monitoring system and, consequently, the increased capacity of applying binding penalties for environmental offenses — was pivotal for reducing forest loss (Assunção et al. 2019b).

FIGURE 2 BRAZILIAN AMAZON DEFORESTATION RATE, 2000-2020



Notes: In 2004, Brazil implemented a federal action plan to combat Amazon deforestation. Within less than a decade, the deforestation rate in the Brazilian Amazon fell by more than 80%. Evidence shows that policies enacted within the scope of the action plan were effective in reducing forest clearings and significantly contributed to the sharp decrease in the deforestation rate. The strengthening of environmental monitoring and law enforcement was pivotal for containing forest loss.

Source: Data from INPE (2021).

Developing effective policy instruments is a necessary condition for protecting the Amazon Forest, but it is not a sufficient one. Political cycles are also fundamentally important for conservation outcomes. The benefits of climate action are diluted across members of society and over time, so politicians often favour measures that will bring them immediate returns. Governments can therefore intentionally undermine existing conservation policies. This has happened before in Brazil, and it is happening again now.

LESSONS LEARNED FROM BRAZIL'S USE OF PUBLIC POLICY TO COMBAT AMAZON DEFORESTATION

Under the federal action plan, Brazil developed a robust policy framework to control deforestation in the Amazon despite limited state capacity and poorly defined property rights. Valuable lessons can be learned from a large, and still growing, literature that evaluates the effectiveness and impacts of the plan's key conservation efforts.[1] Today, there is also mounting evidence regarding important pitfalls and limitations of Brazil's current environmental policy setup.

1 The CPI/PUC-Rio Evidence Pack consolidates the available empirical evidence on the impacts and effectiveness of policies aimed at protecting the Brazilian Amazon.

Monitoring and law enforcement

Deforestation in the Brazilian Amazon has long been an overwhelmingly illegal practice (Schmitt 2015, Azevedo-Ramos et al. 2020, Azevedo et al. 2021). Yet, through the early 2000s, the country had no means of systematically surveilling vast areas of forests. The major leap forward in environmental law enforcement capacity happened with the development of a near-real-time remote monitoring system. Using satellite imagery to cover the full extent of the Brazilian Amazon, the system identified changes in forest cover and, for each of these changes, issued alerts marking the exact location of a detected clearing. Starting in 2005, these alerts became the basis for targeting environmental law enforcement operations on the ground. When caught, environmental offenders could be punished with administrative penalties that carried both a direct financial burden (fines, seized products/equipment) and an indirect one (legal processes and fees). They could also face civil and criminal charges.

With the novel monitoring system, environmental law enforcement authorities could spot illegal activity throughout the entire Brazilian Amazon at unprecedented speed. Assunção et al. (2019b) argue that this was the key to enabling a more targeted and timelier law enforcement response and, thus, to significantly increasing law enforcement's capacity to impose binding and costly penalties. Their estimates indicate that, in the absence of monitoring and law enforcement efforts, the total deforested area in the Brazilian Amazon would have been almost five times greater than what was observed from 2007 to 2016. Stronger environmental control played a critical role in reducing Amazon deforestation.

Monitoring and law enforcement efforts were not only effective for forest protection, but they were also cost-effective, even by very conservative estimates of policy costs and environmental benefits (Assunção et al. 2019b). Furthermore, stricter law enforcement does not appear to have jeopardised local agricultural outcomes, indicating that environmental protection in the Amazon does not pose a threat to agricultural production (Assunção et al. 2019b). Recent evidence also points to relevant policy spillovers. Although strictly meant to combat the loss of primary vegetation, these law enforcement efforts also contributed to the expansion and permanence of secondary vegetation in the Amazon (Assunção et al. 2019a; Barbosa De Oliveira Filho 2020).[2]

Targeting of critical areas

Starting in 2008, Brazil started targeting Amazon municipalities with intense forest clearing activity. This largely consisted of even more rigorous environmental monitoring and law enforcement, but also included efforts to secure land and property rights. These municipalities were annually added to a 'priority list' based on their recent forest clearing history; exiting the list was conditioned upon achieving a sizable and sustained reduction

2 Primary vegetation is that which has never been cleared, while secondary vegetation grows in areas that have already been deforested.

in deforestation. There is a consensus in the literature that the policy effectively curbed deforestation in priority municipalities (Arima et al. 2014, Cisneros et al. 2015, Assunção and Rocha 2019, Assunção et al. 2019c). However, results regarding the mechanisms behind this effect are mixed, with some favouring stricter law enforcement (Arima et al. 2014, Assunção and Rocha 2019) and others suggesting that economic disincentives and reputational risk also played a significant role in inhibiting clearings (Abman 2014, Cisneros et al. 2015). Agricultural outcomes in priority municipalities do not appear to have been affected (Assunção and Rocha 2019, Koch et al. 2019). The policy also reduced deforestation in non-priority neighbouring municipalities (Assunção et al. 2019c).

Conditioning of financial resources

Rural credit is Brazil's main policy support for agricultural production. In an attempt to avoid having subsidised credit contribute to deforestation, the Central Bank of Brazil adopted specific criteria for rural credit concession in the Amazon. In 2008, rural credit became conditioned upon proof of compliance with environmental and land tenure regulations. Conditions were compulsory across financial institutions, but the requirements for some groups were less rigorous, most notably smallholders. Assunção et al. (2020a) show that the policy led to a reduction in total credit concession in the Amazon between 2008 and 2011, and that this, in turn, helped curb forest clearing. These effects were most pronounced in municipalities where cattle ranching was the leading economic activity. The authors interpret this as evidence that, in these municipalities, subsidised financial resources were being used to expand production at the extensive margin, rather than improve productivity.

Protected areas

Although Brazil has long used protected areas as part of its broader conservation strategy, the country promoted a major expansion in protection from 2004 through the early 2010s, protecting more than 52 million hectares of forest. This notable growth in coverage used a new citing strategy that took current and future deforestation risks into consideration. This approach brought true novelty to protection policy during this time. In addition to the original goals of conserving biodiversity and protecting natural habitats, protected areas in high-risk zones were overtly meant to serve as shields against advancing forest clearings. Assunção and Gandour (2018) explore this citing strategy to test for the effectiveness of Amazon protected territories in high-risk zones.[3] Results indicate that

3 There is a large literature assessing the impacts of protected territories in the Amazon. Although there is a general agreement that protection curbs deforestation to some extent, no consensus exists regarding the magnitude of these effects and whether they significantly contributed to the Amazon deforestation slowdown. Estimated impacts vary greatly across regions, time periods and types of protection, including several occurrences of null effects (Pfaff et al. 2014, 2015a, 2015b, Anderson et al. 2016, BenYishay et al. 2017, Kere et al. 2017, Herrera et al. 2019, Baragwanath and Bayi 2020). This diverse set of results should be interpreted in light of significant differences in deforestation risk. Small and null effects are typically attributed to protection being granted to places that were, in practice, far from forest clearing pressures.

these territories operate like a shield, effectively curbing clearings in protected forests. However, the evidence suggests that they deflected deforestation to unprotected regions, thus having a negligible impact on aggregate levels of forest loss.

SECONDARY VEGETATION

In 2014 – the last year for which there is official land use data for deforested areas – there were 17 million hectares of secondary vegetation in the Brazilian Amazon (INPE and Embrapa 2016). This meant that nearly one quarter of the area that had been historically cleared until then had been abandoned, rather than put to productive use such as for agricultural production. Because the Amazon provides favourable conditions for forest regrowth, once abandoned, these areas undergo a process of natural regeneration. On the one hand, this reveals a severely wasteful pattern of land use, reinforcing that deforestation in the Brazilian Amazon is not followed by relevant economic activity. On the other hand, it highlights that there is enormous potential to promote large-scale ecosystem restoration in the region at relatively low cost.

Secondary vegetation in the Brazilian Amazon is, however, completely vulnerable. Brazil's forest monitoring systems were designed to exclusively detect the loss of primary forest, so secondary vegetation is invisible to these systems (Assunção et al. 2020b). As such, it has also been largely ignored by public policy, which has neither significantly promoted nor actively protected forest regrowth. Recent evidence based on unofficial (non-governmental) data shows that the rate of secondary deforestation has increased significantly over the past decade, overtaking that of primary deforestation (Nunes et al. 2020).

Political cycles

After nearly a decade of steep decline, the Amazon deforestation rate started trending upwards in 2012. It has exceeded one million hectares of deforested area per year since 2019. This has been at least partly attributed to a weakening of the institutional context for conservation in Brazil over the past decade, largely due to political pressure (Burgess et al. 2019). Factors contributing to weakened environmental protection in the Amazon include changes to licensing procedures for infrastructure development (Ferreira et al. 2014, Fearnside 2016) as well as regulatory changes and legal disputes regarding the protection of native vegetation inside private properties (Azevedo et al. 2017, Freitas et al. 2018, Santa'Anna and Costa 2021). Descriptive evidence also suggests that environmental control has weakened since the mid-2010s. Public data from the federal environmental law enforcement authority show that, despite increasing deforestation during the period, environmental fines and embargos have fallen to nearly a third and a quarter of their 2015 levels, respectively.

More recently, in what has been regarded as a large-scale and intentional dismantling of policy efforts to combat Amazon deforestation, the current federal administration has severely reduced budgets for environmental control, replaced technical personnel with political appointees, limited the participation of civil society in key decision-making processes, and enacted legislation that weakens environmental control across several topics, including Amazon deforestation (Abessa et al. 2019, Vale et al. 2021). Notably, the federal government also supported regulatory changes to land tenure that largely benefit illegal land grabbers in the Amazon whilst providing only very limited and ineffective environmental safeguards (Chiavari and Lopes 2021a, 2021b). Moreover, it also altered the environmental administrative sanctioning process, rendering it more subject to political control and creating significant legal uncertainty (Lopes and Chiavari 2021). Combined, these measures have drastically intensified the sense of instability regarding environmental control.

LOW-HANGING FRUIT

The Brazilian case illustrates how an effective conservation strategy requires both a strong policy framework and an enabling political environment. Drawing on lessons learned from the country's efforts to combat Amazon deforestation, we propose paths for enhancing the protection of Brazil's native vegetation and, thus, mitigating GHG emissions. We use the available evidence to focus our recommendations on actions that are cost-effective and feasible in the short term. In essence, all recommendations point in the same direction: strengthening environmental command and control is vital and urgent.

Shield environmental law enforcement from political control

Considering that virtually all deforestation in the Amazon is illegal, enforcing environmental law is of paramount importance. The absolute priority must be to combat major institutional instability caused by recent changes to Brazilian environmental governance. This requires ensuring that environmental law enforcement is rid of its current political control and granted independence to act solely on technical grounds. A key step in this direction is to assign personnel with technical expertise to leadership positions at the federal environmental law enforcement agency — many of these positions are currently held by political appointees with no experience in environmental control and with an agenda that disregards forest protection and climate action. Moreover, regulatory changes that weakened the environmental administrative sanctioning procedure must be revised to eliminate political interference and built-in hurdles that render the procedure unfeasible in practice. These are necessary conditions to enable a timely and effective law enforcement response to environmental offenses and, thus, to put an end to impunity for environmental offenders.

Take targeted and strategic policy action

Deforestation in the Brazilian Amazon is spatially concentrated, with only 24 municipalities accounting for half of the total area deforested over the past five years.[4] These are obvious candidates for targeted action to combat deforestation. It is worth highlighting that the priority municipalities policy, designed precisely for the targeting of critical areas, is formally still in place. Its impact, however, depends on effective law enforcement. Furthermore, between a quarter and a third of Amazon deforestation is estimated to occur in undesignated forests under public (federal or state) domain (Azevedo-Ramos and Moutinho 2018, Alencar et al. 2021). Brazilian law prohibits any kind of interference in undesignated forests, so these clearings constitute unequivocally illegal deforestation and illegal land grabbing. Targeting policy efforts to protect these forests is therefore both an environmental and a legal imperative — and, again, one that requires effective law enforcement action.

Improve and integrate official information systems

Although Brazil generates a substantial amount of data for environmental control, its information systems lack transparency, integration, and systematisation. This prevents the country from using these data to their full potential. The use of public resources could be optimized, for example, if law enforcement authorities were able to characterize forest clearings and even differentiate between legal and illegal ones before deploying field operations. This requires data on forest loss hotspots, land tenure, authorisations for the legal suppression of native vegetation, and environmental sanctions. These data already exist, but they are not easily accessed nor integrated across government spheres (federal, state, and municipal) and areas (environment, law enforcement, agriculture, land tenure, among others).

Developing systematised and integrated information systems is not a trivial task, but it is one that is feasible given Brazil's current technical capacity. The country has already taken steps in this direction, experimenting with environmental control action in which there is no deployment of law enforcement personnel to collect information on-site. There is an ongoing project at the Federal Prosecutor's Office that identifies and prosecutes environmental offenders for illegal deforestation using only publicly available georeferenced data, and the federal law enforcement agency has run strictly remote pilot operations to monitor, investigate, and sanction illegal deforestation activities. These efforts, however, are still quite limited in scope. There are also non-governmental initiatives in Brazil that automate data processing and dataset integration to support environmental control. Although encouraging, this does not eliminate the need for policy action to ensure consistent and widespread adoption of data transparency, integration, and systematisation practices at national and subnational levels.

4 Combined, these municipalities account for about 20% of Brazilian Amazon territory.

Move beyond deforestation to boost forest protection

Amazon conservation policy has largely concentrated on combatting primary deforestation, defined as the complete or near-complete clearing of vegetation in an area that has never been cleared before. While this remains essential for protecting native vegetation, it cannot be the sole focus of policy action. Forest protection would benefit from pursuing two additional areas.

First, Brazil needs to enhance its understanding of forest degradation and how to fight it. A degraded forest has lost part of its primary native vegetation, but still retains enough of it to not be considered deforested. Forest degradation occurs at scale in the Brazilian Amazon, with annual measures of degraded areas often surpassing those of deforested areas (Rappaport et al. 2018, Matricardi et al. 2020). Although seemingly less destructive than deforestation, recent estimates indicate that carbon loss to degradation in the Brazilian Amazon has been nearly three times greater than that to deforestation (Qin et al. 2021). Additionally, degradation contributes to the loss of biodiversity, interferes with the forest's provision of ecosystem services, and jeopardizes its resilience, making it more susceptible to further damage (Barlow et al. 2016, Longo et al. 2016, IPCC 2019). In the Brazilian Amazon, forest degradation is typically associated with logging of high-value timber and forest fires. It is still unclear, however, how it relates to deforestation. Gandour et al. (2021) find that there is substantial variation in the rate of conversion of degraded to deforested areas across land tenure categories. For categories exhibiting a high rate of conversion, degradation may serve as a leading indicator of deforestation and, thus, as a relevant input for policy design. The authors argue that targeting degradation could contribute to interrupt environmental damage at an earlier stage and thereby help optimise the use of policy resources while boosting conservation outcomes. Brazil already has the technology to detect forest degradation in the Amazon — the remote monitoring system even classifies alerts according to different types of degradation — and a legal framework that recognises it as an environmental offence. However, Brazilian conservation policy needs to acknowledge the significance of forest degradation for environmental outcomes and provide a timely response.

Second, Brazil must protect secondary vegetation in the Amazon. This requires developing monitoring systems that detect changes to this type of vegetation. Without them, the country cannot adequately monitor compliance with restoration targets at individual property and national levels, nor can it quickly respond to threats to secondary vegetation. Assunção et al. (2020b) argue that Brazil already has the technology and technical expertise needed to develop such systems — what it needs is for policymakers to understand how important protecting secondary vegetation really is. In a context of growing global interest in nature-based solutions, and specifically in voluntary carbon markets, forest regrowth in the Amazon can play a central role in carbon sequestration. It can, moreover, be a particularly cost-effective way of mitigating GHG emissions since natural regeneration is responsible for virtually all secondary growth in the Brazilian Amazon. In addition to being a cost-effective tool for achieving large-scale forest restoration, natural regeneration also enhances the resilience of restored ecosystems (Chazdon and Guarigata 2016). Even if active restoration is needed to recover specific areas, strategic approaches to restoring ecosystems have already been shown to heighten conservation gains and reduce costs (Strassburg et al. 2019).[5] Brazil must therefore not only start monitoring secondary vegetation in the Amazon, but also start thinking strategically about it. The country already has a policy framework for doing this, having enacted a national plan for ecosystem restoration in 2017. Although the plan's execution has been stagnant under the current federal administration, Brazil can use its framework to quickly advance policy efforts to promote and protect forest regrowth.

The past decade has seen Brazil backslide in its efforts to protect the Amazon Forest. This has had dire consequences from environmental, economic, and social standpoints — but not all is lost. Evidence points to low-hanging fruit that will allow the country to make significant progress in the short term, while it works to build other capacities and innovate on new fronts for effective climate action. To reap this fruit, Brazil must address its current lack of an enabling political environment and prioritise the strengthening of environmental command and control policies. This is by no means an easy task, but it is possible and it is worth it.

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CHAPTER 3

Reforming energy subsidies in the Middle East and North Africa: Easy pickings for climate policy or a political bombshell?

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INTRODUCTION

Economists have proposed carbon pricing to reduce the accumulation of greenhouse gas (GHG) emissions that can remain in the atmosphere for centuries and destabilise the global climate (Rezai and van der Ploeg 2014, van den Bremer and van der Ploeg 2021). One approach to putting a price on carbon is to tax GHG emissions based on the carbon content of the fossil fuels that produce them.

The policy debate has shifted from the need for carbon pricing to how to address its distributional implications, such as equity considerations and political feasibility (Klenert et al. 2018). The introduction of a gas tax in France is a case in point. The tax was a major cause of nationwide protests that lasted from late 2018 to the spring of 2021. The 'yellow vest' protests, which resulted in removal of the tax, are a stark reminder of the importance of distributional considerations and the need to garner popular support for bold climate policy action.

In the Middle East and North Africa (MENA) region, energy consumption is heavily subsidised, which has harmful environmental consequences. When energy is subsidised, the prices of energy products are well below those that would prevail under carbon pricing designed to account for environmental externalities. Unsurprisingly, then, many economists and policymakers see reform of energy subsidies, specifically fuel subsidies, as a 'low-hanging fruit' – both as a means to protect the environment as well as a way to create significant fiscal space (Coady et al. 2019).

1 The views expressed in this chapter are those of the authors and do not necessarily represent the views of the African Development Bank and the World Bank.

Energy subsidy reforms, even if accompanied by schemes to compensate consumers, are politically difficult. This is especially true in MENA, because of limited government legitimacy and citizens' distrust of authorities. Moreover, reforms are often reversed after protests erupt.

In this chapter, we argue for a new, holistic approach to reform to account for the frail social contract that has prevailed for decades between the political and economic elites and common citizens in most MENA countries. To sustain needed emission reductions while restoring citizens' trust, authorities in MENA should use the region's vast pool of renewable resources to accelerate the transformation of their energy systems and decarbonise transportation. Authorities must address longstanding issues pertaining to the economic governance of the energy sector, but also complementarities between the energy sector and other sectors – such as finance and transportation – that hamper the transformation of energy systems and their ability to reduce systematically GHG emission.

ENERGY SUBSIDIES, GHG EMISSIONS AND BUDGET DEFICITS

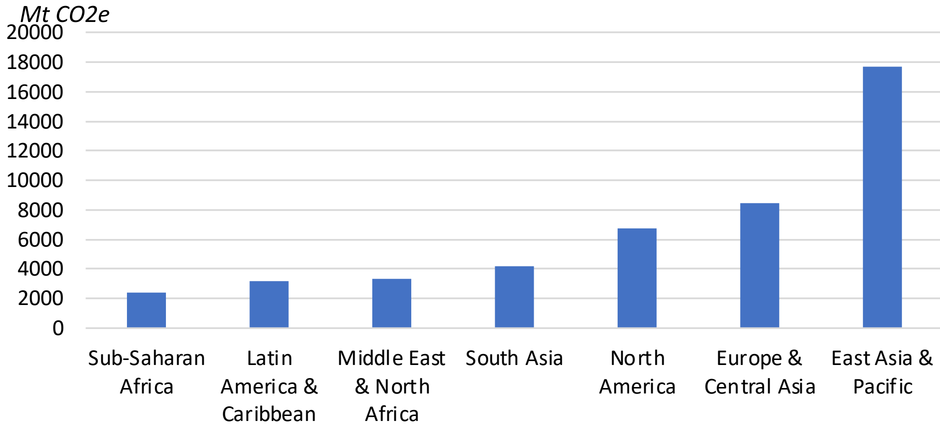
Energy consumption in MENA is heavily subsidised. These subsidies introduce a range of distortions, including wasteful consumption, misallocation, and harmful effects on the environment from local air pollution and traffic congestion (Coady et al. 2019).

Overall, the MENA region produces 3,306 metric tonnes of carbon dioxide equivalent (see Figure 1). That is slightly more than 7% of global GHG emissions even though the region accounts for only 3.5% of global GDP. Saudi Arabia and Iran – with 638 and 828 metric tonnes of CO_2, respectively – are amongst the top ten emitters of GHG emissions globally.

The electricity/heat and transportation sectors are the most important sources of GHG emissions from MENA (see Figure 2). Subsidy rates for fuel, electricity, natural gas, and coal are especially high – among the highest in the world (see Figure 3).[2]

2 A subsidy rate of, say, 10% implies that consumers paid on average around 90% of the competitive market prices for the subsidised energy products (see www.iea.org/topics/energy-subsidies).

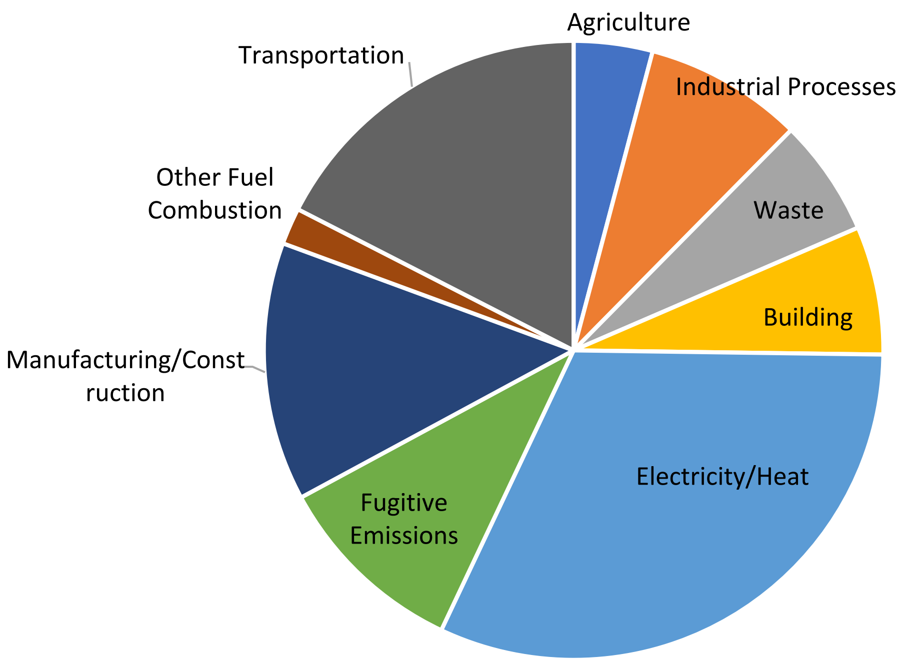
FIGURE 1 GLOBAL GHG EMISSIONS, BY REGION



Note: Mt CO_2e stands for metric tonnes of carbon dioxide equivalent.

Sources: Authors' calculations based on Climate Watch Historical Country Greenhouse Gas Emissions Data (1990-2018), World Resources Institute.

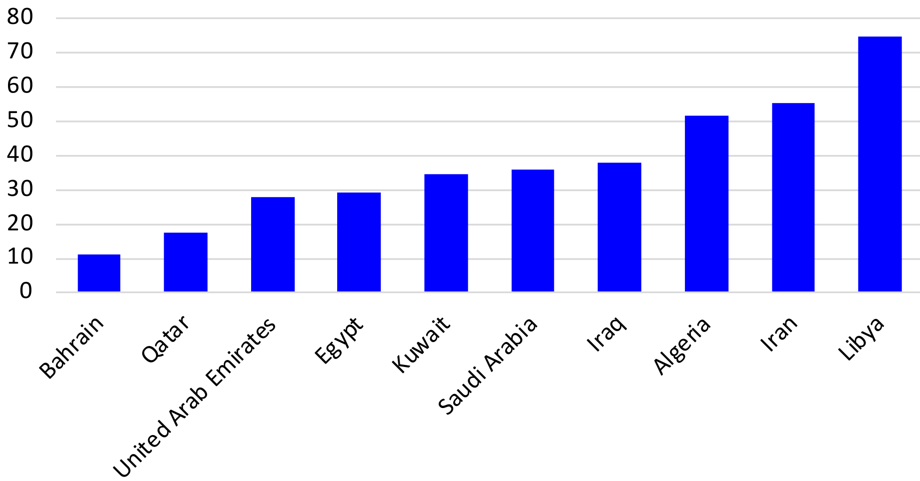
FIGURE 2 SECTORAL DECOMPOSITION OF MENA GHG EMISSIONS



Notes: MENA includes Algeria, Bahrain, Djibouti, Egypt, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Libya, Malta, Morocco, Oman, Qatar, Saudi Arabia, Syria, Tunisia, United Arab Emirates, and Yemen.

Sources: Authors' calculations based on Climate Watch Historical Country Greenhouse Gas Emissions Data (1990-2018), World Resources Institute.

FIGURE 3 AVERAGE SUBSIDISATION RATES IN MENA (PERCENT)

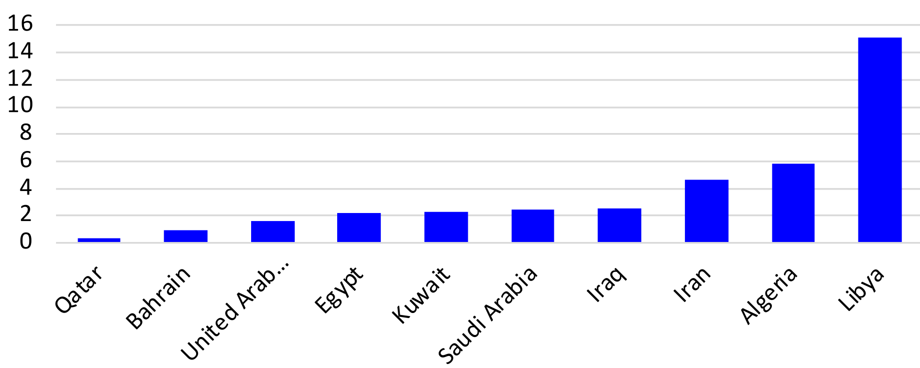


Notes: Data are as of 2020. Subsidies for fossil fuel consumption are measured using a price-gap approach. The approach compares average end-user prices paid by consumers with reference prices that correspond to the full cost of supply. The price gap is the amount by which an end-use price falls short of the reference price and its existence indicates the presence of a subsidy. See www.iea.org/topics/energy-subsidies#methodology-and-assumptions.

Source: International Energy Agency (IEA) website.

Rates can be higher than 50% in Algeria, Iran and Libya. In addition to environmental damages, energy subsidies entail a heavy drain on budgets. The fiscal costs of subsidies in Iran, Algeria and Libya are between 4% and 15% of GDP (see Figure 4).

FIGURE 4 TOTAL ENERGY SUBSIDIES AS A SHARE OF GDP (PERCENT)



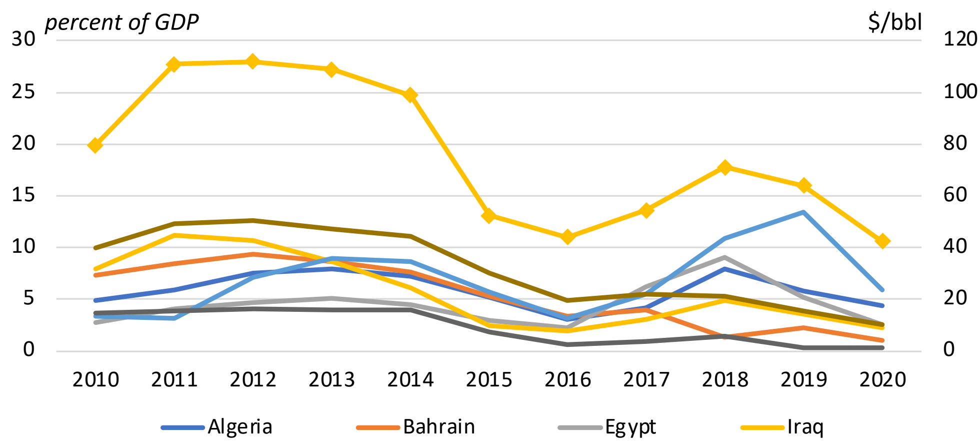
Notes: The chart shows total energy subsidies as a share of GDP as of 2020.

Source: International Energy Agency website.

POLITICAL FEASIBILITY OF ENERGY SUBSIDY REFORM

In principle, energy subsidies in MENA are a low-hanging fruit for climate policy action. But reforming them has proven difficult. Because the region has few functioning social welfare systems, subsidised energy prices are an important part of an inadequate social safety net (El-Katiri and Fattough 2017). Several oil-importing countries in the region have phased out fuel subsidies, but not without difficulties.[3] For the region's oil- and gas- exporting countries, low domestic energy prices have also historically formed an important element of the social contract, in which political elites capture riches from the extraction of hydrocarbons and compensate citizens through a variety of direct and indirect channels, including energy subsidies.

FIGURE 5 FUEL SUBSIDY COSTS AND OIL PRICES



Notes: The top line shows crude oil price in US dollars per barrel. Other lines show total fossil fuel subsidies as a share in GDP.

Sources: Author's calculation based on data from International Energy Agency and World Bank.

The period of persistently low oil prices that started in 2014 when oil prices collapsed has revived the drive to phase out energy subsidies in MENA. It should be politically easier to curtail subsidies when international fuel prices are low because reforming domestic prices would lead to a much smaller price increase than when international prices are high. Not only should reform when international fuel prices are low make curtailed subsidies more acceptable to consumers, it should also help limit the fiscal cost of fuel subsidies when international fuel prices increase again (see Figure 5). Yet, reforming energy subsidies in MENA is much more complex than relying on timing of fluctuations in international fuel prices. It requires a more holistic approach.

3 In 2019, there were riots linked to energy in Lebanon, Iraq and Iran (see McCulloch et al. 2021a).

Still, the urgent need for reforms after periods of delayed stabilisation in MENA has often impelled governments to focus on specific fiscal actions such as fuel subsidies, ignoring or oblivious to the wider consequences. While there is a strong rationale for moving away from universal consumer and producer subsidies because of how heavily subsidies affect the environment and budgets, attempts at reforms have caused protests – at times violent – even when measures were taken to mitigate the effect on the poor.

The rising aspirations of an overwhelmingly educated and young population in MENA contrast with the poor performance of governments in modernising their economies and creating jobs, and provide another source of opposition to subsidy reform. That's because of the distrust generated by the inability of governments in MENA to deliver quality and affordable public services and the (accurate) perception of official corruption that enables a private sector riddled with cronyism. Social media amplifies the discontent (Arezki et al. 2020) by allowing citizens to react swiftly to missteps by often-secretive governments and permitting anti-government sentiments to spread easily.

It is the central role of subsidies in the unspoken social contract that is at the core of the opposition to subsidy reform. That social contract – in which citizens cede their voice and tolerate low government accountability in exchange for subsidies and public sector jobs – is already frayed by dissatisfied young people.

But that dissatisfaction has spread beyond youth as depleting budget coffers in many MENA countries impede delivery of adequate services to the broad population in subsidised sectors such as public transportation. For example, in many countries in MENA, private and mostly informal operators provide most transportation services. These operators have stepped in where the state failed to deliver and, in many ways, the fuel subsidy is a transfer-in-kind to compensate non-state operators for doing the state's job. Removal of a fuel subsidy is perceived by the numerous small operators as a transfer from their pockets to those of a state that has done nothing to deserve it.

Distrust of government, then, is a big impediment to reforming energy subsidies, even when conditional cash transfers programmes compensate losers. According to the Arab Barometer, distrust in government in the region is high: only 25% of the population has a positive view of government performance, while 84% believe there is corruption in state institutions and only 41% believe the government is addressing the issue.

Consequently, it is not uncommon for subsidy reform efforts to be abandoned when governments are faced with street protests or if tensions build up when domestic energy prices increase. As this chapter is being written, countries are still battling the Covid-19 pandemic. Few, if any, MENA countries have considered energy subsidy reforms to create fiscal space, and none have acted. Algeria, for example, approved a 9% cut in public spending in 2020 but kept subsidy policy unchanged to avoid social unrest (Reuters 2020). Evidence from Indonesia and Nigeria indicates that the perception of corruption in the implementation of targeted transfer programmes increases public resistance to fuel subsidy reform among the poor citizens who consume the least fuel and who stand to lose the most from any reductions in targeted programmes (Kyle 2018, McCulloch et al. 2021b).

NEEDED: A NEW APPROACH TO REFORM AND TRANSFORMATION OF ENERGY SYSTEMS

This resistance means a new approach to reform is needed to account for the dynamics of the constantly evolving social contract in MENA. Reform of consumer energy subsidies cannot be considered independently of the implicit producer subsidies – including those to inefficient state-owned enterprises – and the exclusive access many cronies have to public contracts. The approach should articulate a broader vision of economic transformation in MENA aimed at creating a more genuine private sector that addresses economic woes on both the consumer and producer sides. Transformation, including of energy systems and transportation, should also be complemented by a more vibrant social protection system that cushions individuals from bad economic shocks and poverty.[4] Protection systems in MENA countries now are limited, inefficient, and fragmented (Jawad et al. 2019). Well-designed and well-implemented systems will not only make energy reform more widely accepted, they can also encourage more individual risk-taking, fostering entrepreneurship and sustainable private sector development.

Because the inability of many MENA governments to deliver reliable basic services such as electricity and public transportation is at the heart of citizens' distrust, it is essential that before embarking on subsidy reforms, authorities improve government performance and encourage competition in key sectors on which citizens depend.[5] If development of reliable government services were to precede subsidy reform, consumers would be more likely to accept the higher tariffs that would result from reduced subsidies – including the higher fares required to make MENA's public transportation more efficient and more environmentally friendly.

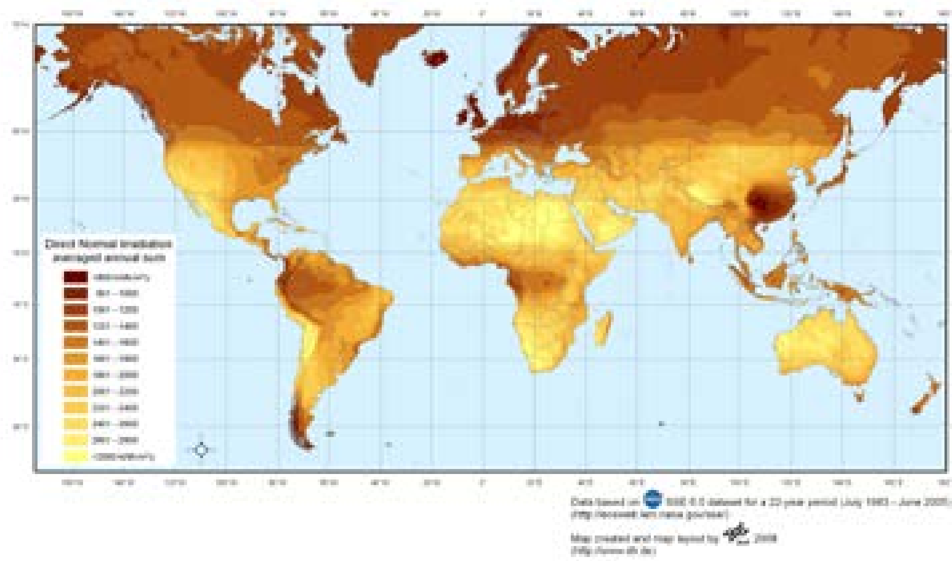
More broadly, if we are to meet climate goals, a large fraction of fossil fuel reserves will need to be kept underground. The MENA region has the largest reserves of hydrocarbon in the world. McGlade and Ekins (2015) estimate that reserves in the Middle East are three times larger than their 'carbon budget'. In other words, 260 billion barrels of oil in the Middle East cannot be burned. In addition to stranded reserves, the structures and capital used in extraction and in exploitation of fossil fuel are also at risk of becoming stranded. [6]

4 See http://datatopics.worldbank.org/aspire/
5 Several economies in MENA are experiencing severe electricity crises (see www.washingtonpost.com/world/middle_east/middle-east-electricity-crisis/2021/07/23/d4dfd9f4-de74-11eb-a27f-8b294930e95b_story.html).
6 One implication of the potential stranded assets is that they could lead to a race to burn the last tonne of carbon. That could in turn lead to a 'green paradox' where regulation aiming to limit carbon emissions ends up raising them instead – at least in the short run (van der Ploeg 2016).

MENA has a huge potential in renewable energy generation that could substitute for subsidized fossil fuel consumption. According to the NASA, solar radiation is highest in the Middle East and North Africa (see Figure 6). The technological changes driving the transition from fossil fuels to renewable sources present sizable economic opportunities for MENA, especially as the cost of renewables such as solar and wind are declining. Authorities in MENA should tap the region's vast pool of renewable resources to accelerate the transformation of their energy systems, which would have the doubly beneficial effect of reducing CHG emissions while keeping energy costs from rising. In isolated and lagging regions, promoting decentralised energy systems could also help economically empower local communities.

The transformation of energy systems in MENA needs to be accelerated. Several MENA economies are already investing heavily in renewables. The United Arab Emirates (an oil-exporting country) and Morocco (an oil importer) are both engaged in ambitious efforts to develop renewable energy resources. The United Arab Emirates wants 30% of the energy used to produce electrical power to come from clean sources by 2030. Morocco, the host of the 2016 United Nations Conference on Climate Change, wants 52% of its installed generating capacity powered by renewables by 2030. Morocco has started to build a massive solar power plant in the Sahara Desert that is expected to have a capacity of two gigawatts, which would make it the world's largest solar power production facility.

FIGURE 6 POTENTIAL FOR SOLAR ENERGY



Notes: The map shows averaged annual sum of the direct normal irradiation around the world.

Sources: US National Aeronautics and Space Administration; and The Institute of Engineering Thermodynamics at the German Aerospace Center.

Overall, installation of new renewable capacity in MENA lags the rest of the world, although growth in the region's use of renewable energy is among the fastest in the world, mainly from a small base (IRENA 2020). In a world in which renewables accounted for at least 70% of total capacity expansion in 2019, renewables accounted for only 26% of net additions in the Middle East.

Transformation in MENA energy systems will require large investment. Luckily, there is growing interest in climate-friendly investments in the global financial community. To tap into that interest, MENA economies must tackle longstanding issues that constrain the ability of their energy systems to absorb investment (Arezki 2021). Sovereign borrowing cannot be the exclusive driver of climate-friendly investment. The private sector, both domestic and foreign, should also be a conduit of climate finance for the continent. Traditionally, high financing costs and tights caps that preclude companies from adjusting tariffs to cover those costs make it difficult to develop bankable purchasing power agreements. Developing decarbonised transportation assets – including railways and other mass transit options – will also help reduce GHG emissions, ensure energy demand predictability and stimulate investment in the electricity sector.

It won't be easy. There are problems related to the economic governance of the energy sector, but also complementarities between the energy sector and other sectors that hamper the ability of MENA economies to absorb investment. In turn, these problems discourage the global investor community. However, if authorities can force the right changes, MENA economies – especially those with little available capital – will be able to tap into the growing interest of global investors in making climate-friendly investments in a socially acceptable manner. And a beneficial side effect would be that the investments would help fix the increasingly onerous and unreliable access to energy and other public services that have exacerbated social tensions.

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CHAPTER 4

No brainers in India

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INTRODUCTION

India emitted only 1.9 tonnes of CO_2 per capita in 2019, well below the world average of 4.7 tonnes per capita. Nevertheless, due to its large population, it is a large emitter, accounting for 7% of global emissions, behind only China, the US, and the EU. Given India's stage of economic growth and wellbeing, its energy demand and material consumption are likely to grow considerably in the coming decades. Achieving these developmental goals while minimising the impact on climate change is the biggest challenge that policymakers in India face – especially in the light of various 2050 net zero emissions targets proposed by different countries. India could propose a more ambitious nationally determined contribution (NDC) which can be developed into an appropriate net zero trajectory in the future.[1] Raising the tax on coal will not only accelerate the integration of renewables with storage but also incentivise efficiency and fuel switching in industrial uses. Setting a mandate of 100% electrification of two- and three-wheelers will mitigate transportation emissions and urban air pollution, and incentivise a transformation of the Indian automobile industry towards the electric mobility future. Finally, with universal electrification and improved electricity supply, electric cooking can play a significant role in supplementing liquid petroleum gas (LPG) and displacing the use of solid fuels in kitchens. This will address the biggest source of black carbon emissions in India. These policies, besides their obvious climate change mitigation benefits, also have significant, and likely higher, co-benefits in mitigating environmental degradation and air pollution and promoting economic development.

1 India's net zero trajectory, whenever it is formulated, is likely to target zero emissions sometime in the second half of the 21st century.

RAISE THE TAX ON COAL

India went through a coal plant building boom between 2005 and 2015. Partly because electricity demand did not grow as fast as anticipated and partly due to competition from wind and solar PV, the prices of which fell dramatically in the last ten years, the coal boom ended in a bust with many plants running well below capacity and their owners in bankruptcy proceedings (Shah 2021).[2]

Coal accounted for 64% of India's CO_2 emissions in 2019[3] with power plants alone contributing about 50% (IEA 2021). In addition to CO_2, coal combustion releases local and regional pollutants such as particulate matter, sulphur dioxide, and oxides of nitrogen. A recent study that accounts for *only* the local pollutants emitted by coal-fired power plants found that they were responsible for an estimated 135,000 deaths in India in 2018. Adding mining and other non-climate damages results in a *domestic* external cost of 2.38 cents/KWh of electricity generated from coal (Chakravarty and Somanathan 2021). This is equivalent to about 2,340 Rs/tonne ($34/tonne) of coal.

India has a coal tax. This was introduced at the rate of 50 Rs/tonne in 2010, raised to 200 Rs/tonne in 2015, and then to its current level of 400 Rs/tonne ($5.8/ton) in 2017 (IISD 2018).[4] The prices paid by power plants for domestic coal range from about 1,000 Rs to 2,000 Rs/tonne, so the coal tax accounts for 20–40% of the price of coal.[5] However, it is still well below the level that would internalise local pollution externalities.

Further financial trouble is looming for the thermal power sector. In 2015, regulations to install scrubbers to remove sulphur dioxide were notified for the first time. Lobbying has resulted in their implementation being delayed into the 2020s. However, it seems unlikely that enforcement can be put off for much longer. These factors, along with a desire to save existing plants from further competition, have led a number of state governments with large coal power capacity – including Gujarat, Chhattisgarh, Maharashtra, and Karnataka – to announce an end to new coal plants (Shah 2021). The country's largest power generation company, the government-owned NTPC, and a large private power company, Jindal, have declared that they will build no new greenfield coal plants (Shah 2021).

An important component of India's INDC is the pledge to raise the non-fossil share of electricity generating capacity to 40% by 2030. This pledge was aided in part by a domestic policy announced in 2016 to expand renewables generation (not counting large hydro) to 175 GW by 2022. In 2019, a more ambitious domestic policy target of 450 GW

2 Government procurement auctions via the National Solar Mission were important in achieving the renewable price decline. In 2019, the price of electricity from solar PV in India was the lowest among the G20 countries.

3 https://ourworldindata.org/grapher/co2-by-source?stackMode=relative&country=~IND

4 This is equivalent to about $3.2/tonne of CO_2.

5 Power plants further from mines pay higher prices due to the cost of transport.

by 2030 was also announced. As a result, India is likely to achieve its INDC target of 40% non-fossil capacity (and 21% generation) in 2021, and can likely reach 60-65% non-fossil capacity (and 40–45% generation) by 2030.

Given the hugely under-priced local pollution externality in the thermal power sector, it makes sense purely from a domestic standpoint to stop growing it and to start shrinking it immediately. This will save money since about a half of the existing capacity has an *operating* cost that is greater than the average cost of new wind and solar PV (Chakravarty and Somanathan 2021). Integration of wind and solar power into the grid is feasible with not much more than regulatory changes until their share more than doubles from its current level of about 10% (Palchak et al. 2017). Further, the social cost of new wind and solar PV *with eight hours of battery storage* is likely to be in the same range as that of new coal plants by 2025 (Chakravarty and Somanathan 2021), and well below that of coal plants by 2030 (IEA 2021).

An immediate national ban on new coal plants is certainly a no brainer. But an increase in the coal tax would be even better. It would accelerate the decline of the coal power sector, and simultaneously choke off any expansion of industrial use of coal released by that decline. Many coal-using industries are small-scale, highly polluting due to inefficient combustion, and hard to regulate, such as brick making. An increase in the coal tax would induce them to reduce pollution and coal use. Increased efficiency and a fuel shift away from coal will further India's INDC on reducing the emissions intensity of GDP. Given the very large pollution damages from coal use, which are probably even greater when used in small-scale industries than in power plants, a rise in the coal tax is economically justified. It is important not to make the increase too abrupt so as to avoid large adjustment costs. Steady increases over time, announced in advance, will allow industries to adjust. Revenues can be used to re-equip industries to use less coal or cleaner fuels, compensate workers who are laid off in the coal industry, and protect low-income consumers from higher electricity prices.[6] Tax increases are never popular, but this has not prevented past increases in the coal tax. It helps that the buyers are industries rather than consumers.

CUT BLACK CARBON EMISSIONS BY ELECTRIFYING COOKING

Black carbon is a powerful short-lived climate forcer. Its impact on snowpacks, glaciers, and ice sheets is significant (Kang et al. 2020) and as much as 40% in the case of pre-monsoon melt of Himalayan glaciers (Gul et al. 2021).[7]

The dominant source of black carbon emissions in India is residential cooking fires (Tibrewal and Venkataraman 2021). Pollution from cooking fires results in a quarter of a million deaths annually (GBD-MAPS Working Group 2018), about 2.5% of all deaths.

6 Any price increase will be moderated by replacement of coal with cheaper renewables.
7 Black carbon is not included in the UNFCCC or its Paris Agreement, but its climate effects are nonetheless real (UNEP 2017).

Improved solid-fuel stoves have had a very limited impact on household air pollution (Pope et al. 2021). Although a recent government programme has greatly expanded access to cooking gas, solid fuels continue to be used alongside, since gas is expensive. Budgetary concerns have led the government to end cooking gas subsidies for all but a class of poor consumers, and even these have faced a price increase.

Improving the reliability of the presently highly unreliable electricity supply, and reimbursing the electricity bills of poor consumers up to a suitable monthly limit, can result in higher uptake of electric cooking. Rural households, when they have the opportunity, use electric cooking in place of solid fuels, resulting in large declines in household emissions of particulate matter that is high in black carbon (Somanathan et al. 2021). Proceeds from coal tax increases can be used to finance low-income households' electricity consumption. Reliability can be improved by tightening regulations to penalise distribution companies for blacking out customers, raising prices to cover costs of distribution improvements, and introducing time-of-day pricing to induce demand responses to costs in a system with a growing renewable share. Improving reliability and subsidising the poor will be popular. The difficulties will lie in the price increases necessary to invest in improved infrastructure, but again, these have been done in the past, suggesting that they are politically feasible.

MANDATE 100% ELECTRIC TWO- AND THREE-WHEELER VEHICLES BY 2030

India is the world's largest manufacturer and exporter of, and market for, two-wheeler (2W) and three-wheeler (3W) vehicles. Two-wheelers like scooters and motorcycles are mostly used for personal transport, while three-wheelers are primarily commercial vehicles used as small taxis and light trucks. Some 85% of India's automobile sales are in the 2W/3W segment. India's 2W/3W fleet accounted for 65% of total petrol consumption and contributed 2% of India's CO2 emissions in 2019 (IEA 2021, PIB 2014). About 0.8% of the 16 million 2W production and 23% of the 600,000 3W production in pandemic-hit 2020-21 was electric (SIAM 2021, KPMG 2020). India's 2W fleet is expected to more than double to 50.6 million by 2026, so accelerated electrification of 2W mobility can make a significant difference to India and the world (Rokadiya et al. 2021).

The current Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) policy provides a cash subsidy of 15–20% on the price of a 2W/3W vehicle. The FAME policy is supported by a taxation policy that taxes electric vehicles (EVs) at 5%, compared to 28% for conventional vehicles.

The 2W/3W segment is the early mover in the EV domain in India. The vehicles require relatively simple charging infrastructure (often limited to home charging), and low or no range anxiety given usage patterns. Battery swapping as an enabling technology is significantly easier in the 2W/3W segment. The 2W/3W segment is already at parity on metrics such as total cost of operation, which explains the rapid growth in this segment even before the FAME schemes (KPMG 2020). Personal sales of EV two-wheelers are estimated to reach 7–10% of sales by 2025 and 25–35% by 2030. The corresponding figure for three-wheelers and commercial sales of two-wheelers to delivery companies is about 30–45% by 2025 and 60–75% by 2030 (KPMG 2020). The higher figure for business/commercial sales reflects the low total cost of operation compared to similar ICE vehicles.

The current policy framework doesn't provide a clear signal for investments, and doesn't go far enough. We suggest that a mandate of 100% electrification of 2W/3W production by 2030 (with 50% achievement by 2026) is the type of ambitious but 'no brainer' policy that is required. This would provide the right long-term policy signal, with interim milestones, to transform the Indian automobile sector towards the electric mobility future. The mandate would have these components that need to be fleshed out with (1) a sunset policy for the production of conventional two-wheelers, (2) lower tax and subsidy incentives for new purchases, (3) production-linked incentives to promote manufacturing of electric 2W/3W and large lithium battery manufacturing facilities, and (4) policy and incentives for charging infrastructure.

The benefit to the country in terms of reduced oil import bills, lower emissions and urban pollution are obvious. Compared to conventional 2W/3Ws, EVs are projected to have emissions that are 77% lower (Anup et al. 2021). A 100% EV mandate would lead to a transformation and increased global competitiveness of the Indian automobile sector. This policy would directly contribute to the INDC on reducing the emissions intensity of GDP. The mandate would also incentivise the necessary investment in large lithium battery manufacturing facilities that will generate economies of scale, and further contribute to lowering the cost of EVs in the passenger car, bus and freight vehicle segment.

The sunset policy for conventional two-wheelers will undoubtedly meet with industry opposition, but as recent experience with the Bharat Stage VI emission standards for new vehicles has shown, this can be overcome without any great adverse consequences for the growth of the industry.

CONCLUSION

The three no brainers discussed above are some of the most obvious policies that would have a significant impact on emissions growth. These also have the benefit of being simple to implement because decisions can largely be taken at the federal level. States can add to these policies with local policies to further enhance their implementation.

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CHAPTER 5

Climate policy towards carbon neutrality in China

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EVOLUTION OF CHINA'S CLIMATE COMMITMENTS

China's stance toward international climate negotiations has been evolving concurrent with changes in domestic and international contexts. While China has been very active in participating in international climate negotiations and undertaking domestic climate mitigation and adaptation measures since the early days of climate talks, there is a discrepancy between its domestic actions and its simultaneous reticence to act at the international level. In line with changing domestic and international contexts, China has been recalibrating its stance and strategy, and is widely seen as playing an increasingly positive role in this complex process (Zhang 2017).

In previous papers (Zhang 2000a, 2000b), I envisioned that China could make a voluntary commitment to total greenhouse gas emissions per unit of GDP at some point around 2020, and that a combination of a targeted carbon intensity level with an emissions cap at the sector level would be the most stringent commitment that it could make around 2020. It was only just prior to the Copenhagen climate summit in 2009 that China pledged to cut its carbon intensity by 40–45% by 2020 relative to its 2005 levels. While this is consistent with China's longstanding opposition to hard emissions caps on the ground that such limits will restrict its economic growth, this marked a point of departure from its longstanding position on its own climate actions.

In subsequent papers (Zhang 2009, 2011a, 2011b), I argued that there was room for a further increase in China's climate commitments. Based on a balanced analysis, I suggested a 46–50% cut in its carbon intensity by 2020 (this turned out to be what China actually achieved – China's carbon intensity was reduced by 48.4% by 2020) and that China needed to take on absolute emissions caps around 2030. At the Paris climate summit, China committed for the first time to an absolute emissions target, aiming to cap its carbon emissions around 2030 and to try to peak early, as well as to increase the share of non-fossil fuel use to around 20% by 2030 (NDRC 2015).

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At the general debate of the 75th session of the United Nations General Assembly in September 2020, Chinese President Xi Jinping announced that China aims to have a carbon emissions peak before 2030 and to achieve carbon neutrality before 2060. This not only strengthens China's previous commitment to peaking around 2030, but also adds the new commitment to carbon neutrality before 2060. Several studies have suggested that China can do that, so the commitment to peak before 2030 may not be surprising. For example, the Global Energy Interconnection Development and Cooperation Organization suggests that China's coal consumption will peak by 2025 and carbon emissions will peak around 2028 (GEIDO 2021). However, the new commitment to carbon neutrality came as a complete surprise to both international and Chinese experts. The pledge is not bowing to international pressure, and nor is it conditioned on other countries' commitments.

TABLE 1 CHINA'S ENERGY AND CLIMATE GOALS FROM THE 11TH FIVE-YEAR PLAN (FYP) TO 2060

Time frames	Target goals
11th FYP (2006–10)	Cut energy use per unit of GDP by 20% (actually achieved: 19.1%) relative to 2005 levels; close small thermal power plants with a total capacity of 50 gigawatts (GW) (actually achieved: 76.8 GW); save 100 million tons of coal equivalent (tce) cumulatively (actually achieved: 150 million tce) through the Top 1000 Enterprises Energy Conservation Action Program.
12th FYP (2011–15)	Cut energy intensity by 16% and carbon intensity by 17% relative to 2010 levels (actually achieved: 18.2% and 20%, respectively); save a cumulative 250 million tce through the 10,000 Enterprises Energy Conservation Low Carbon Action Program.
13th FYP (2016–20)	Cut energy intensity by 15% and carbon intensity by 18% relative to 2015 levels (actually achieved: 14% and 18.2%, respectively); set absolute limit for energy consumption of 5 billion tce (actually achieved: 4.98 billion tce); cut carbon intensity by 40–45% relative to 2005 levels (actually achieved: 48.4%) and have alternative energy sources to meet 15% of national energy consumption (actually achieved: 15.8%).
14th FYP (2021–25)	Cut energy intensity by 13.5% and carbon intensity by 18% relative to 2020 levels.
Year 2030	Cap carbon emissions before 2030; reduce carbon intensity by 65% or more compared to 2005 levels; increase the share of non-fossil fuels to 25%; total installed capacity combined for wind power and photovoltaics amounts to at least 1200 GW.
Year 2060	Achieve carbon neutrality before 2060.

The new pledge constrains China's carbon pathways after 2030. Without the commitment to carbon neutrality, theoretically speaking, there could be a variety of emissions pathways after carbon peaking around 2030. One pathway could be that emissions stay at the peak level for a while and gradually decline. Another could even aim to peak at a very high level to enable to leave more space for future development and emissions.

A variety of global models suggest that meeting the 2°C target would require a peak of China's carbon emissions over 2020–25, and that China's emissions must decrease very quickly afterwards (Tavoni et al. 2015). The commitment to carbon neutrality limits all these possibilities because the aforementioned pathways will significantly increase the difficulty of achieving carbon neutrality before 2060. Chen et al. (2021) show that to achieve carbon neutrality by 2060, China will need to achieve a carbon emissions reduction rate of no less than 6% per year and a carbon capture capacity growth rate of more than 10% per year. The carbon emissions reduction rate will be even higher, up to 8-10% per year, if carbon capture capacity grows much slowly (Tsinghua University 2020).

TRANSFORMATION OF THE ECONOMIC STRUCTURE AT AN UNPRECEDENTED PACE

If it materialises, China's pledge alone will lower warming projections by 0.16°C–0.30 °C, the biggest reduction ever estimated from a single policy measure (Climate Action Tracker 2020, Chen et al. 2021). However, this will not be easy. For the EU and US, there is period of 45-60 years from carbon peaking to carbon neutrality; for China, the period is only about 30 years. Moreover, China's absolute emissions are twice those of the US, the world's second largest emitter (BP 2021). So, the pace and scale of carbon reduction after China's carbon peaks will need to far exceed those of any other county in the world.

In comparison with other countries at its income level, China has an unusually large share of energy-intensive industrial production and an unusually small share of the less energy-intensive services sector. Moreover, the differing composition of industry affects the levels of energy intensity. China has a large share of energy-intensive manufacturing in industry (World Bank 2020). It is common sense that industry consumes much more energy than services per unit of value added. While the share of industry has been below half of the whole economy in China, industry still consumes the majority of fossil fuels and emits most of the carbon. Compared with industrialised countries, China's industrial processes have not been energy efficient. This, combined with a large population, unprecedented urbanisation and a coal-fuelled, energy-inefficient and rapidly growing economy, makes China the world's largest carbon emitter. Its status as the workshop of the world also leads to a hefty chunk of China's carbon emissions being embodied in goods that are exported to industrialised countries as well as to other developing countries (Zhang 2012, Zhang et al. 2020).

Just as people tend to underestimate the impact of technological change, people usually underestimate the effect of economic structural transformation. Grubb et al. (2015) found that major failures in energy and emissions projections can frequently be accounted for in retrospect by failures to anticipate such major economic structural shifts. Given that power generation, iron and steel, and cement emit about 70% of China's total carbon emissions, achieving the dual carbon goals requires low-carbon transformation of the Chinese economic structure at an unprecedented pace. It was economic restructuring and upgrading that contributed most to meeting a set of China's energy-saving and environmental goals over the past decades, and they are expected to continue to play that role. So, policies aimed at that should be given priority. As such, traditional energy-intensive industries with high emissions will face capacity reductions and, accordingly, investment in fixed assets in energy-intensive industries with high emissions will be reduced.

Indeed, China has taken unprecedented action to reduce excess capacity in energy-intensive industries such iron and steel, cement, coal, and aluminium in recent years, and has put in place very strict regulations for adding new capacity to these industries. However, some local governments believe that as the country committed to carbon peaking before 2030, this means that there are still nearly 10 years of carbon emissions growth to go. So the intention of 'rushing to the peak' has emerged, trying to build a batch of energy-intensive projects with high emissions as soon as possible and striving for higher peak levels of carbon emissions.

However, higher peak levels will make it harder to achieve the carbon neutrality goal by 2060. Therefore, the decisions in the politburo meetings of the CPC Central Committee in both April and July 2021 – the highest-level meetings of policymaking in China – further emphasised that any high energy-consuming and high-emission projects that do not meet the energy and environmental requirements must be resolutely taken down. Moreover, to ensure provincial governments are fully aware of the importance of energy saving and emissions reductions and their responsibilities, the National Development and Reform Commission released a barometer for achieving the dual control targets for energy consumption in each region in the first half of 2021. It also held a press conference where it publicly warned that nine provinces had become even more energy intensive in the first half of 2021 and that, in ten provinces, the rate of reduction of energy intensity in the first half of the year was below the scheduled rate (Peoplenet 2021). All of this clearly reflects the central government's determination not only to implement deliberate policy and practice towards transformation towards low-carbon green economy but also to achieve the expected outcomes.

ORDERLY PHASING-OUT OF COAL-FIRED POWER AND INCREASING THE CLEAN ENERGY SHARE

Carbon neutrality requires a deep adjustment of the energy consumption structure to a low-carbon and eventually non-carbon one, and accordingly the energy supply structure needs to match this change. Given that about 85% of carbon emissions in China come from burning fossil fuels and that China's energy mix is coal-dominated, logically this means that efforts should target reducing coal production and use.

Coal use for power generation accounts for more than half of total coal production in China. While for the first time total nationwide coal-fired installed capacity was below half of the total installed power capacity by 2020, nationwide 1,080 GW of coal-fired power has been under operation. Also, the majority of existing plants were built less than 15 years ago (Global Energy Monitor 2021) and thus have a remaining lifetime of 20–30 years. GEIDCO (2021) suggests that coal-fired power will not be phased out in China until 2060 under the commitment to carbon neutrality, although its share in the national total installed power capacity will drop down to 4% by 2050.

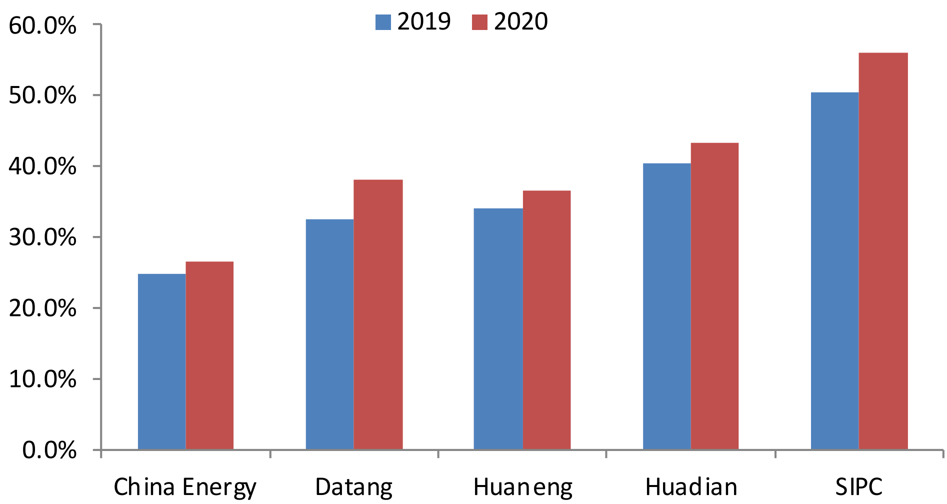
The issue, then, is that as long as the majority of existing coal-fired plants are operating, it is impossible for coal to peak. On the other hand, the retirement of these plants too quickly would be too costly.

There are two ways out of this dilemma to avoid risking stranded assets in China. One is to establish a plant-by-plant plan for the phasing-out of coal power in China under the carbon neutrality constraint. Cui et al. (2021) identify a total of 111 GW of capacity as 'low-hanging fruit' – that is, plants that are particularly suited to rapid near-term retirement. Rapid retirement of the low-hanging fruit would allow other existing plants to operate with a 20-year or 30-year minimum lifetime without carbon capture and storage (CCS) and to gradually reduce utilisation to complete phasing-out by 2045 and 2055 under the 1.5°C and 2°C climate goals, respectively (Cui et al. 2021). If implemented, rapid retirement of the low-hanging fruit and reduced operating hours for other existing plants will significantly reduce coal use and therefore carbon emissions.

Another way of avoiding stranded coal-fired power assets is to rely on CCS technologies to enable existing plants to operate more time in the lifetime. As cost upper bound of zero carbon technologies, CCS acts as the last resort if there is no other lower-cost option available for achieving zero carbon emissions. With CCS, these existing coal-fired power plants may not retire at a faster pace. But CCS is still in the early stages with very limited capacity. China's CCS capacity of about 40 CCS pilot projects under operation or construction totalled about three million tCO_2 in 2020 (Cai et al., 2021), which is far short of the required capacity to meet the need. The pace of CCS cost reduction and scale of CCS deployment in the future will affect the extent to which coal use is reduced in China.

The five largest national power-generating groups in China – China Energy Investment Corporation (China Energy), Huaneng Group, Huadian Group, State Power Investment Corporation (SIPC), and Datang Group – can play a crucial role in this transformation process. These large SOEs have committed to clean energy and have been increasing the clean energy share in their operations. SIPC stands out from others in terms of both installed clean energy capacity and its share in the total installed capacity. SIPC owns the world's largest installed capacity of renewable energy, and its share of clean energy in the total installed capacity rose to 56% in 2020 – 30% higher than the share of China Energy, the largest national power-generating group. SIPC is also the first central government-owned enterprise in China to announce a schedule for achieving carbon peaking, committing to a carbon peak by 2023. Huadian is expected to achieve carbon peaking by 2025, and Datang is committed to carbon peaking before 2030, with the share of non-fossil fuel-powered capacity increasing to more than 90%.With the total non-fossil fuel-powered installed capacity exceeding 1000 GW for the first time by the end of June 2021, the China Electricity Council (2021) projects that total non-fossil fuel-powered installed capacity will exceed that of coal-fired power by the end of 2021, and its share in the national total installed power capacity will increase to more than 90% by 2050 (Tsinghua University 2020, GEIDO 2021).

FIGURE 1 SHARE OF CLEAN ENERGY IN TOTAL INSTALLED CAPACITY FROM THE FIVE LARGEST NATIONAL POWER-GENERATING GROUPS IN CHINA, 2019-20



THE NATIONAL CARBON TRADING SCHEME NEEDS FURTHER EXPANSION

China has implemented a variety of programmes and initiatives, as well as supporting economic and industrial policies and measures, targeted at energy saving and pollution cutting over the past two decades. The country needs to further strengthen and expand these programmes and initiatives, and the supporting policies, to keep China's energy demand and pollution under control (Zhang 2016).

However, these are necessary but not enough. To achieve both a carbon peak and carbon neutrality requires huge capital investment in the field of renewable energy, cross-regional power transmission, advanced energy storage, charging stations and hydrogen refuelling stations in the transportation field, end-use electrification, green buildings, and energy saving and emissions abating. A variety of studies project different outcomes, but all the forecasts for required investment exceed CNY 100 trillion over the next 40 years (Tsinghua University 2020, GEIDO 2021, Yi 2021). Government finance can cover only a small portion of investment on such a huge scale. The significant gap must be made up by social capital, which must be guided by market-oriented approaches. The carbon market can play just such a role, providing market carbon price signals, incentivising and attracting resources to tilt towards low-carbon green projects, promoting green and low-carbon development, and achieving the aforementioned dual carbon goals while helping entities cut emissions at the lowest cost.

In late October 2011, the National Development and Reform Commission approved seven pilot carbon trading schemes in Beijing, Chongqing, Guangdong, Hubei, Shanghai, Shenzhen, and Tianjin. By June 2014, all seven carbon trading pilots had started trading, covering a total of 2,837 entities in 20 sectors. By June 2021, the total accumulated volume of traded allowances for all seven carbon trading pilots reached 480 million tons of CO_2, and the total accumulated value of traded allowances reached CNY 11.4 billion, with the average price of CNY 23.8 per tonne of allowance traded (SCIO 2021). Generally speaking, these carbon trading pilots have provided valuable references to improve the design, operation and compliance of such schemes and to develop a national emissions trading scheme, and they have achieved their expected outcomes to some extent (Zhang 2015, SCIO 2021).

However, the volume of allowances traded in each pilot market is small, and there is a lack of liquidity. Also, the carbon price is so low as to seriously affect incentives for investment in energy saving and emissions abating. The national carbon emissions trading covers 2,225 power-generation plants, each emitting at least 26,000 tonnes of CO_2 equivalent per year (MOEE 2020a, 2020b). Altogether, the power plants covered under the national carbon trading scheme emit over 4 billion tonnes of CO_2 emissions, accounting for about 40% of the national total carbon emissions. Since it began trading on 16 July 2021, on the whole, the national carbon market has operated smoothly. The carbon price has not experienced sharp fluctuations, and the price has fluctuated within a reasonable range. However, from the perspective of trading volume of allowances, apart from the first day when the trading volume reached 4 million tonnes, the daily trading volume has basically been less than 200,000 tonnes, and between 10 and 1,000 tonnes on some days. Trading activity thus still needs to be improved.

Launching the national carbon market with the power generation sector is a good start point and will help form a carbon price signal across the whole society. Under the premise of ensuring its smooth and standardized operation after the launching of carbon trading across the country, it is necessary to accelerate the expansion of the participating industries and the scope of the carbon market. Iron and steel, and cement industry account for over 25% of the national carbon emissions, and should be given priority for inclusion of the national carbon trading scheme. Further coverage expands to industries such as petrochemical, chemicals, other building materials, nonferrous metals, papermaking, and aviation in the next five years. As such, about 70% of the national total carbon emissions are covered under the national trading scheme. That will enable carbon pricing to play a crucial role in incentivizing energy-saving and carbon abating, and ensure the dual carbon goals to be met at the least cost.

Currently, China's national carbon trading scheme only covers the power generation sector. Because electricity tariffs continue to be regulated by the central government, power-generating plants have to bear all the incremental costs of carbon abatement and are not allowed to pass through the carbon costs incurred. Therefore, coal-fired power plants have no desire for a high carbon price because they cannot afford it on their own. This leads to the situation in which carbon prices do not reach reasonable levels for the emission abatement purpose. Moreover, carbon prices cannot play a role in prompting economic restructuring and the upgrading of downstream industries on the power consumption side.

Implementing emissions trading in the power sector creates a new impetus for power pricing reform to allow the pass-through of carbon costs in the electricity sector. However, the reality in China suggests that a comprehensive power pricing reform may not come any time soon. Until this long-awaited reform is undertaken, we must look for other options to reflect the carbon costs in power generation. Just as coal-fired power plants that are mandated to install desulfurisation and denitrification facilities receive a power price premium for desulfurisation and denitrification (Zhang 2014), the National Development and Reform Commission – the sole organisation in China that is mandated to set and change power prices – could offer a power price premium for carbon abatement. If the central government decides to take this option, that price premium for carbon abatement would be offered nationwide to all fossil fuel-fired power plants for their carbon abatement, not only those included in the carbon trading schemes (Zhang 2015).

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CHAPTER 6

From quick wins to big wins: Policies for structural transformation and low-carbon growth in China

Martin Raiser and Sebastian Eckardt[1]
World Bank

INTRODUCTION

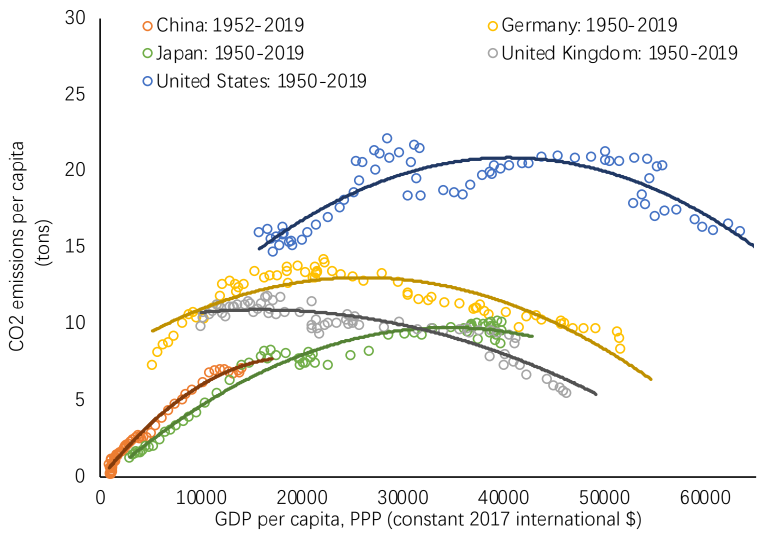
China has pledged to achieve peak carbon emissions before 2030 and carbon neutrality by 2060. As the world's largest emitter of greenhouse gases (GHGs), accomplishing these goals will make an essential contribution to mitigating global climate risks. The pledge – if achieved – is expected to make the biggest single contribution by any country to global climate goals, estimated to reduce global warming forecasts by 0.2–0.3°C by 2100, independent of the actions of other countries.[2] Especially with its densely populated coastal areas, large parts of China's population and economic infrastructure are also heavily exposed to the impacts of climate change. Early climate action is thus both in China's own and the global interest.

IS CHINA DECOUPLING? DISSECTING EMISSIONS AND OUTPUT GROWTH

Achieving China's climate goals will require a decoupling of output growth from emissions at much lower levels of per capita income and per capita emissions than in high-income countries (Figure 1). Historically, China has exhibited the same strong link between economic growth and rising emissions that was characteristic of earlier episodes of economic development and industrialisation. Both total GHG emissions and carbon emissions have quadrupled since 1990 and now account for 26% and 29% of global emissions, respectively. While China's per capita emissions (8.2 tCO_2e) are significantly lower than those of the US, they surpass those of the EU (7.1 tCO_2e).

1 The views expressed in this chapter are the authors'own and should not be attributed to the World Bank. The authors gratefully acknowledge excellent research assistance by Yusha Li and Qinxuan Zhang.
2 https://climateactiontracker.org/press/china-carbon-neutral-before-2060-would-lower-warming-projections-by-around-2-to-3-tenths-of-a-degree/

FIGURE 1 DECOUPLING OUTPUT AND CARBON EMISSIONS GROWTH



Source: World Bank staff based on data from Global Carbon Project, Penn World Table 10.0.

Encouragingly, after soaring in the 2000s following China's accession to the WTO,[3] the growth of China's carbon emissions has slowed in the past decade. Starting with the 12th Five-Year Plan (2011–2015), a policy shift towards more environmentally sustainable, lower carbon growth has been pursued.[4] As a result, China's carbon emission growth dropped from an average of 9.4% year-on-year in the 2000s to an average of 1.1% year-on-year in the 2010s (Figure 2), putting China on track to meet its 2030 nationally determined contributions (NDCs) under the Paris Agreement.[5]

China's decarbonisation strategy has so far relied heavily on efforts to reduce energy intensity and shift the energy mix towards renewable generation. In combination, these two factors have contributed the largest proportion to improvements in the emissions intensity of GDP. Between 2011and 2017, they accounted for more than 80% of the total abated emissions, with structural transformation – a shift in the composition of GDP away from energy and carbon intensive activities – accounting for the remaining 18% (Figure 3). The policies underpinning these shifts included administrative caps on coal consumption and residential energy use, support for improving efficiency of coal-fired generators, feed-in subsidies for renewable energy capacity, support for smart grids and electric vehicles as well as mandatory energy efficiency targets in energy-intensive industries (National Development and Reform Commission 2016).

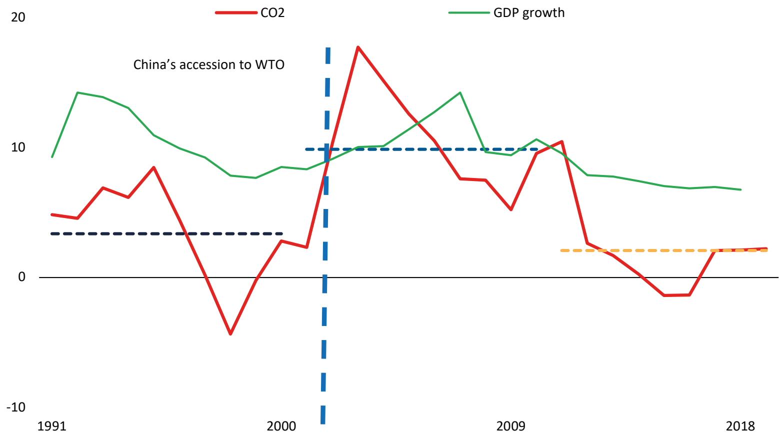
3 Peng et al. (2015) argue that one-third of production-based emissions following WTO accession served final demands of the advanced economies.

4 Following China's pledge at the UNFCCC Copenhagen Climate Change Conference in Copenhagen in late 2009 to cut carbon intensity of GDP by 40–45% from its 2005 level and to increase the non-fossil energy share to 15% by 2020, the 12th Five-Year Plan was the first plan to set a carbon intensity target (CO_2 emissions per unit of GDP) (Li and Wang 2012).

5 China's NDCs under the Paris Agreement include 60–65% lower CO_2 emissions per unit of GDP from 2005 levels, and CO_2 emissions peaking by around 2030.

FIGURE 2 GDP AND CO_2 EMISSION GROWTH IN CHINA

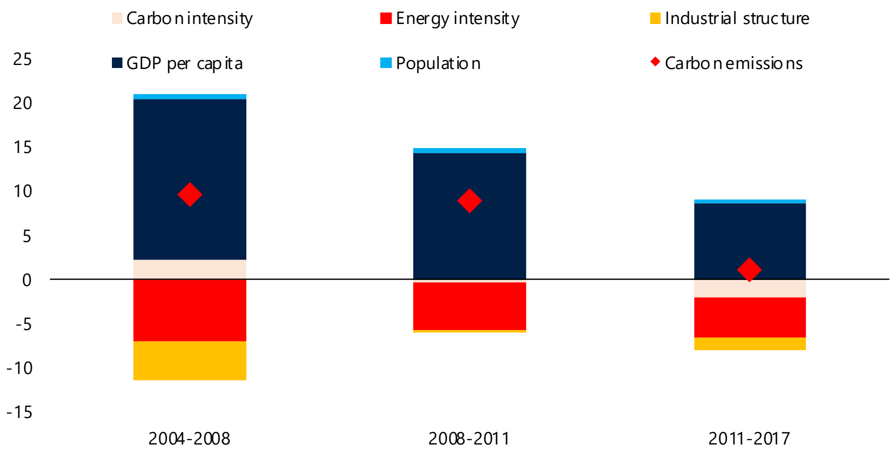
(%, year-on-year)



Source: World Bank staff based on data from Global Carbon Project, National Bureau of Statistics of China.

FIGURE 3 DRIVERS OF CHINA'S CARBON EMISSIONS GROWTH

(percentage points, contribution to growth)



Note: We use the time series decomposition method Log-Mean Divisia Index (LMDI) to decompose the change in carbon emissions of nine sectors of the Chinese economy over the period 2004-2017.

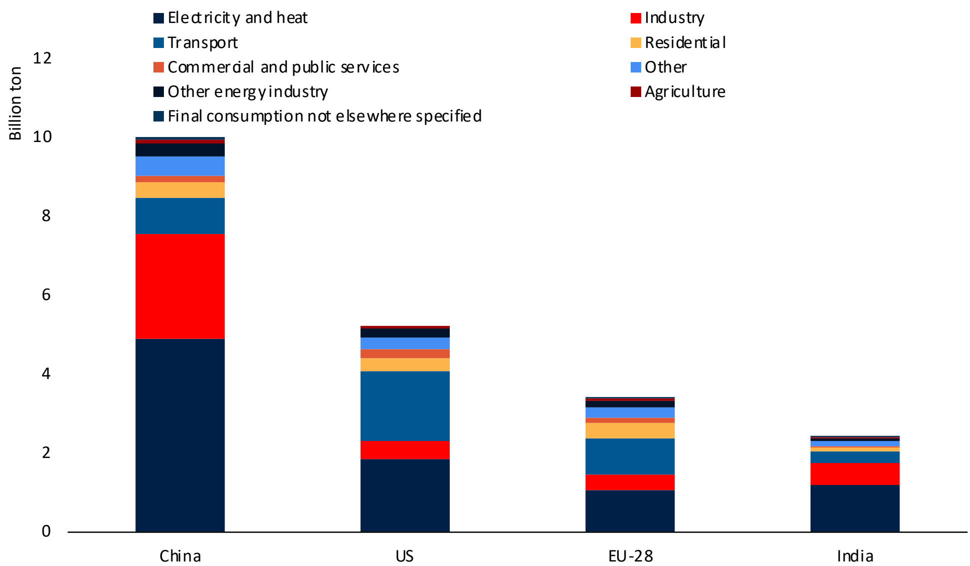
Source: World Bank staff based on data from Carbon Emission Accounts and Datasets (CEADS), National Bureau of Statistics of China.

The rapid scaling-up of non-fossil electricity generation has been a key driver of lower emissions growth. Over the past decade, China has become the world's largest investor in renewable energy, with installed capacity of 990 gigawatts. The renewable share in China's energy matrix increased from 8.7% in 2010 to 13.2% in 2019. Conversely, the share of coal generation saw a slow but steady decline – by about one percentage point per year. Nonetheless, China's power sector remains heavily coal-dependent, with coal accounting for 64.7% of total generation, and as such remains the largest contributor to the country's CO_2 emissions.

In addition, China has made strides in reducing the energy intensity of its large industrial sector. The energy intensity of China's GDP declined by an average of 3.5% per year over the past decade. These gains reflect both mandatory energy efficiency policies (the Top 1,000 and Top 10,000 programmes) and a gradual shift from energy-intensive towards higher-value activities in machinery and chemicals (IEA 2020a). Nonetheless, industrial emissions remain exceptionally large, accounting for 28% of total emissions – much higher than in the US and EU (Figure 4). Carbon emissions from steel manufacturing alone still account for more than 15% of China's total (Zhou 2021). This is mainly because heavy industries – steel, cement, and other construction materials – continue to be a very large part China's economy.

FIGURE 4 CHINA'S LARGE INDUSTRIAL SECTOR WILL BE HARD TO DECARBONISE

Energy-related CO_2 emissions by sector



Source: World Bank staff based on data from International Energy Agency (IEA).

RAISING SHORT-TERM AMBITION

Following its long-term carbon neutrality pledge, China also revised its 2030 goals in December 2019.[6] It committed to cut CO_2 intensity by over 65% from the 2005 level; increase the share of non-fossil fuels in primary energy consumption to 25%; increase the forest stock volume by 6 billion m^3 from the 2005 level; and reach 1,200 GW of solar and wind power generating capacity. This is an increase over the 2016 NDC, but largely in

6 President Xi Jinping made these commitments as part of speech at the Climate Action summit organised by the UN.

line with previous trends and without a clear signal to cap coal consumption or absolute emissions. In other words, China's revised 2030 targets suggest significant but relatively gradual progress until 2030, followed by an acceleration thereafter.

This has triggered a debate over whether China could raise the short-term ambition of its climate goals.[7] In this chapter, we argue that it could, but that this would entail embracing a more rapid structural transformation of China's economy and greater reliance on market-based policy instruments. Both may face political resistance but could be phased in with the help of long-term policy guidance – a tool China is well used to. Raising ambition in this way, moreover, holds the promise of triggering a new round of innovation that would more than offset any short-term costs. We now go through these arguments step by step.

THE CHALLENGE OF PEAKING CARBON EMISSIONS

China's renewable energy and energy efficiency targets are not trivial. The ambitious build-up of renewable capacities, particularly solar and wind, and their safe integration into the grid is beset with technical and institutional difficulties. Depending on assumptions about growth in energy consumption and other non-fossil energy sources, including nuclear, China will need to install between 110 GW and 140 GW of wind and solar capacity each year from 2021 to 2030 – the equivalent of Germany's entire installed renewable capacity (Myllyvirta 2020). At the same, China's planners consider that further installation of coal-fired capacity will be required during the 14th Five-Year Plan to secure the country's energy needs. Under current plans, peak coal may thus be a few years away still.

China also aims for continued reductions in emissions intensity by 18% over the period 2021 to 2025. While this appears feasible, the prospects for further gains in reducing industrial process emissions are becoming increasingly limited as China's energy efficiency levels approach the global frontier. For heavy industries that generate significant process emissions, such as steel and cement, low-carbon production technologies remain costly (hydrogen and carbon capture in steel production) or do not yet exist (cement). Without major technological breakthroughs, abatement in these economically important sectors will be challenging.

These considerations suggest the pathway to carbon neutrality will likely need to involve a more fundamental restructuring of the economy (Green and Stern 2017). Abating the significant emissions from China's large industrial sector will require either a significant reduction in the share of heavy industries in GDP or the development and marketisation of new cost-effective technologies to decarbonise industrial production processes. China's short-term climate goals can be understood as a wager on the emergence of such technologies after 2030 and the desire to smooth the process of structural transformation

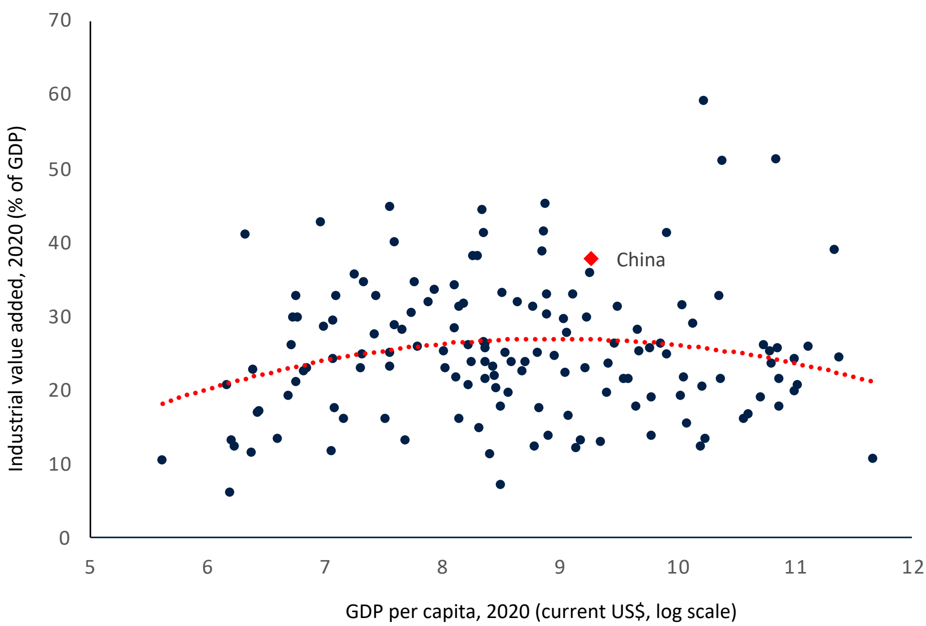
7 The appropriate level of ambition to achieve global climate goals is obviously dependent on what other countries are prepared to do, and this in turn may depend on China's own commitments. In this article, we abstract from these strategic global considerations and focus on what China could do from the perspective of reaching its own long-term goals.

and deindustrialisation that the path toward net zero is likely to require. This is consistent with a policy preference for regulatory over market-based measures to drive emission reductions, calibrated to each sector and frequently adjusted.

MANAGING STRUCTURAL TRANSFORMATION

China's economy remains more dependent on industry than those of other countries at similar levels of per capita incomes (Figure 5). The share of industry in GDP has been declining from a peak of 42% in 2006 to 32% in 2019, slowing the growth of emissions. Administrative measures to reduce overcapacity in heavy industries, especially steel, have contributed to this structural change.[8] Yet, policymakers have recently warned local governments against excessive administrative interventions that could unduly hurt growth and employment. China's 14th Five-Year Plan also emphasises manufacturing as a continued driver of growth.[9] A key concern of China's policymakers is thus managing the structural transformation that the path towards net zero is likely to entail.

FIGURE 5 INDUSTRIAL VALUE ADDED AND GDP PER CAPITA
(% of GDP; current US$)



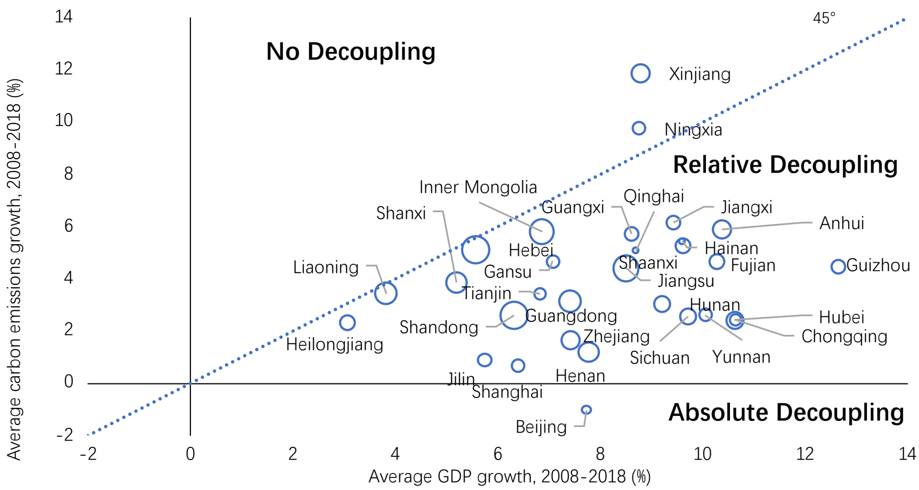
Source: World Bank staff based on data from World Development Indicators (WDI).

8 For example, in 2016 alone the government laid off 15% of the respective workforce in a movement to downsize China's steel and coal industries (source: State Council Information Office official website at www.scio.gov.cn/xwfbh/xwbfbh/wqfbh/33978/34234/index.htm).

9 In a notable departure from the 13th Five-Year Plan, the 14th Five-Year Plan removed the target for the service sector share in GDP to rise and instead calls for the manufacturing share to remain "basically stable".

One challenge of an accelerated low-carbon structural transformation relates to its asymmetric regional impacts. Given stark differences in economic structures, the carbon footprint varies significantly across provinces. Beijing has already passed peak emissions, partly reflecting the relocation of carbon-intensive industries to other provinces (often explicitly encouraged by administrative means) and the emergence of a modern service economy. Many other coastal and some interior provinces are also approaching peak emissions (Du et al. 2017). In contrast, emissions continue to outpace GDP in Ningxia and Xinjiang and also continue to increase rapidly in coal-dependent provinces such as Shanxi and Inner Mongolia (Figure 6). Similarly, GDP remains much more carbon intensive in some of the interior provinces. For instance, emissions per unit of output in Ningxia are 7 and 11 times higher than in Shanghai and Beijing, respectively.

FIGURE 6 ASSYMMETRIC DECOUPLING



Source: World Bank staff based on data from Carbon Emission Accounts and Datasets (CEADs), National Bureau of Statistics of China.

The regional pattern of emissions growth is closely associated with China's investment-driven growth model. In the past decade, many of China's interior provinces have experienced an enormous investment boom, which has contributed to reducing the large development gap between the coastal and western provinces but was associated with rising emissions (World Bank 2020). However, the economic rate of return of these investments is increasingly questionable, as reflected in rapidly rising incremental capital output ratios. Even during the 2020 recovery, investment in infrastructure and real estate has been associated with emissions growth, reflecting the preponderance of 'brown' over 'green' stimulus measures in China's COVID-19 response.[10] This suggests that China's

10 See the Vivid Economics 'Greenness of Stimulus Index' at www.vivideconomics.com/casestudy/greenness-for-stimulus-index/

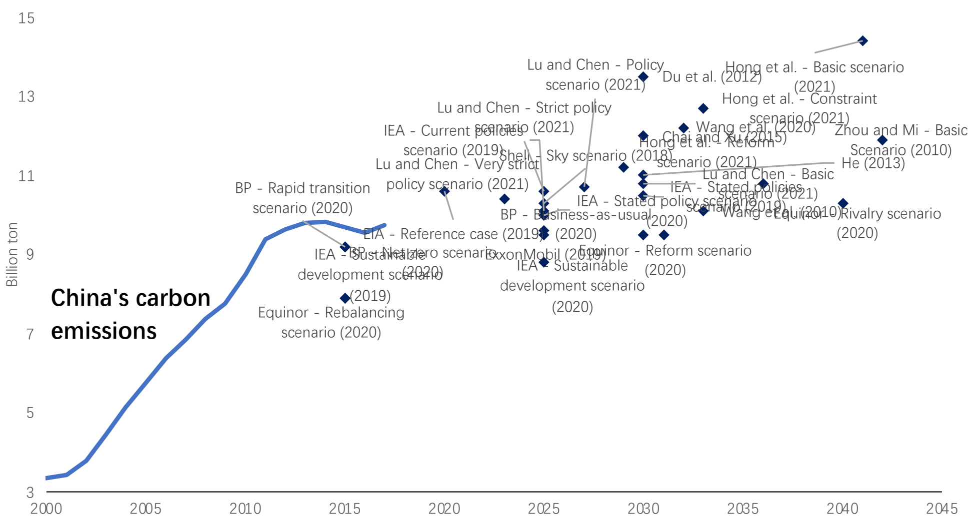
current policy mix is insufficient to induce the required structural transformation. Further 'quick wins' may not be possible unless China makes climate action a central part of its innovation drive.

THE PROMISE OF A SCHUMPETERIAN CLIMATE INNOVATION BOOST

Proponents of more ambitious climate action argue that waiting for new technologies to emerge ignores the central role of government policy in inducing climate innovations and driving more rapid decarbonisation through public investment particularly when real interest rates are as low as today.[11] With a shrinking global carbon budget, taking action now, especially in areas where technological solutions are available would help preserve critical room for manoeuvre that may needed in hard-to-abate areas. For China, various models suggest that with appropriate policies peaking well before the end of this decade is a realistic proposition (Figure 7). In the past, China has consistently exceeded its initial targets – meeting both commitments related to the reduction of carbon intensity of GDP and the non-fossil share in the primary energy mix well ahead of schedule. The current targets formulated as peaking emissions "before 2030" and cutting CO_2 intensity by "over 65%" also leave room for increased ambition.

FIGURE 7 REACHING THE PEAK

Estimates of carbon peak level and year from various macroeconomic models



Source: World Bank staff based on data from World Bank Staff based on various published research papers.

11 For a comprehensive treatment of the potential for climate action to unleash a new round of Schumpeterian innovation, see Stern (2015), A more recent application of these arguments to China can be found in Stern and Xie (2021). A similar argument for the case of Europe is made in Victoria et al. (2020).

To turn higher ambition into reality, however, an augmented policy mix is likely required.[12] China's ability to steer its economy through regulatory means, coupled with industry-specific subsidies and other incentives, is not to be underestimated. However, the current approach runs counter to the notion of climate change as a catalyst of Schumpeterian innovation, characterised by significant uncertainty over future technological developments. Stimulating innovation at the production possibility frontier requires policies to stimulate competition and provide appropriate price signals (Aghion 2017, Blanchard and Tirole 2021).[13] China is well positioned to benefit as a first-mover from these technological shifts. Already today China is the largest market for investment in green technologies from electric vehicles to renewable energy and more than half of the world's direct and indirect jobs in the renewable energy sector are in China.

GETTING PRICES RIGHT

Adequate and broad-based carbon pricing could help drive China's structural transformation and achieve economy-wide and cost-effective abatement (Stiglitz et al. 2017). Price instruments have important advantages over regulatory interventions: they do not require policymakers to accumulate information about which specific activities and investments to select to achieve the most efficient abatement path. Regulatory measures in specific industries, on the other hand, may lead to distortions in the allocation of resources and generate abatement costs significantly above the social cost of carbon.[14]

Earlier this year, China put in place a national emissions trading scheme (ETS), effectively the largest carbon market in the world with a trading volume of roughly 4 billion tonnes of CO_2, or roughly 12% of total global CO_2 emissions. The ETS is an important initial step, but its role in driving low carbon development could be enhanced in several ways.[15]

Under the scheme, about 2,200 of China's largest coal- and gas-fired power plants are allocated free emissions rights. The initial phase of market development is focused on building credible emissions disclosure and verification systems – the basic infrastructure of any functioning carbon market – encouraging facilities to accurately monitor and report their emissions rather than constraining them. Allocations granted to power companies have been relatively generous and are tied to power output and current levels of carbon intensity rather than being set at absolute levels. In addition, requirements of each individual facility to obtain additional emission rights are capped at 20% above the initial allowance and fines for non-compliance are relatively low. Consequently, the initial

12 Similar arguments are made in Black et al. (forthcoming).
13 A report by the World Bank and the Development Research Council of China (2019) makes similar arguments.
14 Michael Greenstone has argued that some government programs to subsidize specific investments, such as energy efficiency upgrades of residential buildings can cost much more than the carbon benefits they deliver. (e.g. Fowlie et al. 2018).
15 See also www.imf.org/en/News/Articles/2021/04/15/sp041521-securing-a-green-recovery

trading price has been relatively low at Rmb 48 per tonne (US$7.4 at the exchange on the launch date of 16 July 2021) and is unlikely to rise much for the time being, mitigating the immediate financial impact on power producers and giving them time to adjust.

For carbon pricing to develop into a significant policy tool, total emissions and individual allowances will need to tighten. Estimates by Tsinghua University suggest that carbon prices will need to increase to at least $300–350 per tonne by 2060 to achieve carbon neutrality. Our own research at the World Bank indicates that a broadly applied carbon price of $50 could help reduce China's CO_2 emissions by almost 25% compared to business as usual over the coming decade, while also contributing significantly to reduced air pollution (Black 2020).

Providing forward guidance on a predictable path for annual emissions cap reductions could smoothen the transition, allowing power producers to factor future carbon price increases into their investment decisions today.[16] A relative straight forward first step could be the incorporation of a mass-based emissions cap into China's climate action plan, now under elaboration. Emission allowances under the ETS could then be set at an absolute level applied uniformly to all types of power plants – as is done in the EU and other carbon markets. With a clear forward path for absolute emission allowances, it is doubtful that power producers would have any incentives to invest in additional coal fired capacity.

For price signals – including those from the ETS – to be effective, power producers also need to compete, allowing less polluting and more efficient ones to expand their market share. This is currently not the case in China, where the power market remains heavily controlled, interprovincial trade is limited, and the dispatch system continues to allocate fixed quotas to coal. Complemented with public investments in transmission lines and changes in dispatch rules, carbon pricing could drive an even faster expansion of renewable capacity – including a breakthrough in cost-effective storage technologies and decentralized power supply.

As the market develops, carbon pricing should become an economy-wide instrument. The power sector accounts for around 30% of domestic carbon emissions, but to meet China's climate goals, mitigation actions are needed in all sectors of the economy. The authorities plan to expand the ETS to petro-chemicals, steel and other heavy industries over time. In light of the decarbonisation challenges in those sectors, this emphasis is well placed. In other carbon-intensive sectors, such as transport, agriculture and construction, emissions trading will be technically challenging because monitoring and verification of emissions is difficult. Faced with similar challenges, several countries in the EU have

16 As investments in both carbon-intensive and green assets are largely irreversible ('putty clay'), a predictable path of carbon prices can help reduce risks of capital misallocation. For a conceptual discussion of this point see Olijslagers et al. (2021).

introduced complementary carbon taxes applied to sectors not covered by an ETS. Such carbon excise taxes are a relatively simple and efficient instrument, charged in proportion to the carbon content of fuel and a set carbon price.

Finally, while free allowances are still granted to some sectors in the EU and other more mature national carbon markets, annual emissions rights are auctioned off. This not only ensures consistent market-based price signals, but also generates public revenue that can be recycled back into the economy to subsidise abatements costs, offset negative social impacts or rebalance the tax mix by cutting taxes on labour, general consumption or profits.[17]

CARBON PRICING IS NO PANACEA

Carbon pricing may be necessary but is likely insufficient to engender the transition towards a zero-carbon economy. To provide effective signals to innovators and investors, carbon prices need to be credible and reasonably predictable. In addition to a predictable path for emissions, a transparent market-supporting infrastructure is also needed. An initial step in this direction would be to require all large corporate and financial institutions to disclose their scope 3 emissions and have them independently verified, ensuring a transparent basis for emissions trading and taxation and mitigating the risk of political resistance because of perceived biases.

In addition, public financing may be required to catalyse R&D and lower risks for private investors in low-carbon technologies (Norberg-Bohm 2000, Mazzucato 2015, 2016). Like other emerging market economies, China has the advantage that parts of its transportation, energy and urban systems are still being built out, creating an opportunity to invest in more resilient, low-carbon infrastructure from the outset rather than locking in carbon-dependent technologies and assets. However, in contrast to most other developing counties, China's investment rate is already exceptionally high and the challenge is not to scale up investment but rather to shift its allocation decisively in the direction of low-carbon activities and technologies.

The transition to a greener growth path also implies a faster exit from polluting industries which will cause labour dislocation and financial losses. As a result, firms and workers in carbon-intensive sectors such as coal, cement, steel, and other heavy industries will face significant transition risks. Some coal-mining communities and regions are especially at risk because of a lack of alternative job opportunities. In some communities, place-based policies may be successful in creating new jobs. But in general, the low-carbon transition will need to be complemented with more flexible capital and labour markets to enable a more efficient economic adjustment. More robust social safety nets are also

17 Simulations have shown that revenue neutral carbon tax reforms can reduce the non-nvironmental welfare losses otherwise associated with carbon taxes and under certain circumstances, such as large informal sectors, even result in a more efficient, less distortive tax system (Carson et al. 2019).

needed to protect workers and investments in reskilling to enable them to find alternative employment. This may lead to a shift in the geographical distribution of China's growth back to coastal areas that are better positioned to benefit from an innovation-based and services-oriented growth model.

In sum, China's policymakers may find that the new drivers of growth they have been seeking require a very similar set of policy measures as putting their economy on the path towards net zero emissions. That would turn quick wins into big wins.

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CHAPTER 7

Opportunities for fast and cost-effective decarbonisation in Russia[1]

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Russia is the world's largest country by territory, with 20% of global forests, 10% of arable land and fossil fuel reserves of over 350 billion tonnes of oil equivalent (toe). Russia is currently the fourth-largest emitter of greenhouse gases (GHGs) with 1,585 MtCO2e of annual emissions (as of 2019), including forest and land use. Between 1990 and 2000, national GHG emissions declined by 54%, mostly due to the economic crisis and GDP drop in the 1990s, demilitarisation and a restructuring of the economy, the expansion of service sectors and a substantial increase in carbon sequestration by forests primarily caused by reduced wood harvesting. However, the economic recovery and fast growth in the 2000s has led to a steady 12% rise in domestic GHG emissions (Roshydromet 2021).

Russia is a party to the United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement. However, its nationally determined contribution (NDC) includes a very weak emissions reduction target of 30% below 1990 levels by 2030,[2] meaning that national emissions may be increased by 36% from the current level. This lack of ambition in mitigation efforts can be explained by the country's vast resources of fossil fuels, the absence of incentives for decarbonisation and the willingness of policymakers and businesses to preserve the existing economic model based on the export of carbon-intensive goods and fossil fuels. This is well reflected in strategic socioeconomic development documents, such as the Energy Strategy by 2035 (Ministry of Energy 2020a), which forecasts further growth in the production, consumption and export of coal, gas and petroleum over the next 15 years. Producers of ferrous and non-ferrous metals, chemical fertilizers, cement and other commodities with high carbon footprints also expect to avoid transitioning to zero-carbon options in the coming decade.

Numerous macroeconomic and sectoral studies have demonstrated that there is a huge mitigation potential in Russia at rather low and even negative costs. McKinsey (2009) analysed 60 measures in various sectors that could help reduce energy consumption by 23% and GHG emissions by 19% by 2030, compared to a business-as-usual scenario. The

1 This chapter was prepared within the framework of a research grant funded by the Ministry of Science and Higher Education of the Russian Federation (grant ID: 075-15-2020-928).
2 www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Russian%20Federation%20First/NDC_RF_eng.pdf

capital investment of 0.8% of the GDP per year by 2050 can allow Russia to improve energy efficiency and switch to low-carbon technologies (Bashmakov 2009). The deep decarbonisation pathways for Russia are diverse and allow reducing carbon emissions by 87% below 2010 levels by 2050 (SDSN and IDDRI 2014, 2015). The incremental annual cost for deep decarbonisation in energy-related sectors was projected to be around US$12 billion by 2030, $25 billion by 2040 and $42 billion by 2050.

So, what are the low-hanging fruit in mitigation in Russia?

IMPROVEMENT IN ENERGY EFFICIENCY

Total primary energy consumption in Russia could be reduced by 45% via energy efficiency in both production and consumption (IFC/World Bank 2014). More specifically, by realising its huge energy efficiency potential, Russia could save 240 billion cubic metres of natural gas, 340 billion kWh of electricity, 89 million tonnes of coal and 43 million tonnes of crude oil and petroleum products. The total capital and operational costs of full-scale energy efficiency measures are estimated at $320 billion, while the annual costs savings to investors and energy consumers reach $80 billion, paying back in just four years. The overall benefits to the national economy, society and environment could reach $120–150 billion per annum.

Large-scale energy efficiency measures could help Russia to maintain competitiveness in international markets, increase export earnings, reduce costs associated with the high energy intensity of production and lower the state budget expenditures. They could also reduce or avoid the environmental costs of air and water pollution, ecosystem degradation and health risks. The World Bank estimated these benefits to be as high as $140-170 billion per year (IFC/World Bank 2014).

The cheapest and fastest results in reducing GHG emissions via energy efficiency could be gained by implementing effective awareness-raising campaigns, flexible budgeting and procurement rules in public organisations and the commercialisation of municipal heat supply systems. Other measures with potentially massive impact but higher costs include the introduction and enforcement of energy efficiency standards in buildings and industrial equipment, fuel efficiency, strong demand-side management, financial incentives for capital renovation and strengthening the heat supply networks.

The high-cost, high-return policy options in energy efficiency include energy tariff reforms, further liberalisation of electricity and gas markets, the reduction and removal of energy subsidies, integrated transport planning, enhancing technological requirements and environmental control systems.

RENEWABLE ENERGY SOURCES (RES)

Russia owns huge RES that can provide zero-carbon alternatives to fossil fuels both for domestic supply and export. The RES technological potential is estimated at over 11,500 Mtoe per annum (Bezrukikh et al. 2007), which is 25 times higher than the total primary energy produced in the country annually. This includes:

- Micro- and small-hydro: 100 Mtoe/year
- Biomass: 120 Mtoe/year
- Low potential heat: 170 Mtoe/year
- Wind: 2,000 Mtoe/year
- Solar: 9,200 Mtoe/year.

The costs of green power generation have been declining in the last decades. For example, solar PV costs dropped ten-fold in the last decade.[3] These cost reduction trends will allow green energy sources in Russia to be utilised much more effectively if the appropriate legal and institutional frameworks are in place. Currently, Russia's renewables (excluding large hydro) generate around 1% of its total electricity (IPEM 2021). By 2024, the government plans to increase the capacity of RES from under 1 GW to 5.9 GW, mostly by focusing on wind, solar and small hydro (Ministry of Energy 2021). The barriers to RES expansion in Russia include continuing pressure from fossil fuel lobbyists, excessive technical requirements for RES installations and the strict standards for RES equipment localisation.

METHANE EMISSIONS

Methane emissions account for 22% of total GHG emissions in Russia (as of 2019). The main sources include fugitive CH_4 emissions from coal extraction, gas supply systems and associated petroleum gas (APG) (50%), waste management (29%) and livestock (13%) (Roshydromet 2021).

The technologies for methane emissions in the main gas pipelines and local gas distribution networks are relatively cheap and a source of GHG emissions reductions. However, the regulatory frameworks must be improved for this to occur. For example, the 'technological' losses of methane (during maintenance works or accidents in the gas pipelines) are still an extremely small cost for Gazprom and other gas companies (these costs are included in the state-regulated gas tariffs for the population and businesses).

3 www.irena.org/costs

APG flaring has been regulated and ambitious targets have been set (up to 95% of APG must be utilised), but not all companies comply with such strict requirements and some continue to emit huge amounts of methane at their facilities in remote areas.

The technologies for reducing methane emissions from coal mines and other coal-related sources are well known and relatively affordable. However, venting methane from coal mines is still widely used in Russia. The utilisation of methane from landfills is also technologically feasible, but the waste management sector is under the control of strong lobbyists and almost no new technologies have been applied in this area so far. A few projects in landfill methane utilisation were initiated in Russia under the Kyoto Protocol to UNFCCC that showed economic effectiveness, but without further expansion due to weak financial incentives and administrative barriers. The manure management activities aimed at methane emission reduction could be very cost-effective, if mitigation effects can be capitalised.

HYDROGEN PRODUCTION

A highly relevant 'decarbonisation pillar' for Russia relates to the rising demand for hydrogen around the world. In late 2020, Russia adopted a plan for developing its hydrogen energy strategy by 2024, setting a highly ambitious target of a 20% share of the world market in this decade (Ministry of Energy 2020b).

There are some technological and scientific foundations for boosting hydrogen production in Russia, and the existing gas pipeline network may help with its transportation to export markets. 'Grey' hydrogen produced from natural gas is currently the easiest option for Russia, an example being Gazprom's proposal to open some plants in Germany to produce hydrogen from imported Russian natural gas (TASS 2020). 'Orange' hydrogen made using nuclear power is also possible due to excessive power generation by the state-owned Rosatom Corporation. However, the main potential export markets of the EU, Japan, Korea and North America prefer 'green' hydrogen based on zero-carbon electrolysis using RES. This might be an option if RES expansion were made a higher political priority or businesses were to face rising demand for green hydrogen. There is some evidence of that at present. The energy company En+ plans to start producing 18,000 tonnes of hydrogen per year based on its existing hydropower plants in Siberia and Karelia, and is considering investing $1.3 billion in the construction of a new hydropower plant with 1 GW capacity for the production of 118,000 tonnes of green hydrogen per year (Kommersant 2021). The H2 Clean Energy company (owned by a major Russian gold producer) has announced the development of a tidal energy project in Kamchatka with up to 100 GW capacity for green hydrogen production (TASS 2021).

SECOND-GENERATION BIOFUELS

Biofuels produced using organic matter are in high demand on the world markets. Russia possesses huge amounts of biomass for this purpose, including wood waste, low-grade wood and agricultural residues. The overall amount of biomass waste generated is estimated at 200–400 Mt per year from forestry and 150 Mt per year from agriculture (Bezrukikh et al. 2007). Most of this biomass is not utilised so far.

Various technologies are known and available:

- The production of **bio-kerosene** (extremely important for the reduction of CO_2 emissions in international and domestic aviation) and **bio-gasoline** for automobiles (corresponding to the Euro-5 standards but with zero carbon emissions) based on innovative technologies is feasible. A technology with an affordable catalyser to produce liquid biofuels was invented at the Institute of Catalysis. But while the production costs are lower than in a crude oil refinery, the widespread application of this innovation requires reform of the regulatory framework (e.g. a reduction in the access tax for liquid biofuels) and governmental support of distribution and logistics.
- **Biocharcoal** can substitute for traditional energetic coal for power plants, with much less pollution and a zero carbon footprint. There is a huge demand for biocharcoal worldwide. Domestic energy companies can also use biocharcoal for power and heat generation without any adjustment to existing boilers and other technologies.
- **Biogas** technologies utilising organic waste represent an affordable alternative to natural gas, as has been demonstrated in China and many other countries. The Belgorod region is positioned to be one of the pioneers in biogas production from livestock manure in the country. The existing regulatory framework for gas supply creates barriers for the expansion of biogas utilisation (from landfills, manure, etc.) due to the low concentration of methane gas produced, but this could be easily overcome if a stronger mitigation policy is adopted.

CARBON CAPTURE AND STORAGE (CCS)

CCS technologies could potentially play a role in the reduction of CO_2 emissions in the Russian energy sector. A pioneering feasibility study of carbon capture in the Kuzbass coal region was launched in 2020. The capacity of injecting CO_2 into local coal mines will be analysed based on the international experience with dozens of CCS projects worldwide. CCS costs are expected to decline by 2025 and beyond (Irlam 2017), so the implementation of CCS projects may provide Russia with an opportunity to produce coal- and gas-based energy without emitting CO_2. So far, CCS technologies are applied by Russian oil companies to enhance crude oil extraction.

N_2O EMISSIONS

The production and consumption of chemical fertilizers is a major source of N_2O emissions in Russia. There are various technological options for substantial reductions in N_2O emissions at fertilizer production facilities. For example, in 2010-2012, the leading domestic producer, Akron, revealed a project to change a catalyser to eliminate large amounts of N_2O emissions, but then refused to implement it (probably due to low carbon prices under the Kyoto Protocol). Emissions reductions can also be achieved by reducing chemical fertilizer use and changing practices in agriculture (e.g. switching to no-till technologies for crop production). Total N_2O emissions from inorganic N-based fertilizers and the cultivation of organic soils have reached about 30 MtCO2e per year and continue to rise (Roshydromet 2021).

CARBON REMOVAL BY FORESTS

Russia's huge forests provide substantial mitigation opportunities through carbon sequestration and the production of wood-based products and materials. In the last decade, carbon removal from forests declined from 750 to 620 $MtCO_2$ per year, primarily due to extending wildfires, tree diseases and rising wood logging. The potential in increasing carbon absorption relates to protecting the forest from negative anthropogenic and natural impacts, the improvement of forest management, forest planting and the (re)creation of soil-protective forest belts in agricultural areas, which have suffered from poor management and have degraded in most provinces in the last 30 years. Both Russian and foreign companies are highly interested in forest projects that may provide carbon offsets. The demand for domestic offsets is already about 20-30 $MtCO_2$ per year.

Another important field of mitigation activity within the forestry sector involves the substitution of carbon-intensive products and materials with wood- and plant-based alternatives. Instead of traditional cement, concrete, steel and plastic, Russia could produce large amounts of wooden houses and construction materials, bio-chemicals, plastics and even biotextiles. This would not only reduce GHG emissions but also sequester and store carbon for decades to come. The annual potential for emission reduction is estimated up to 63 $MtCO_2e$ just for domestic wooden housing needs (Leskinen et al. 2020).

LAND-USE CHANGE

Switching to new climate-friendly practices in agriculture also provides enormous opportunities for mitigation in Russia. No-till and mini-till technologies allow large amounts of carbon in soil to be saved and accumulated, while planting highly nutritious plants instead of using chemical fertilizers and fuel-saving reduces GHG emissions. The spread of no-tillage systems to over 110 million hectares worldwide shows the great adaptability of the systems to all kinds of climates, soils and crop conditions (Deprsch et al. 2010). In the relatively small Altai region of Russia, over 700,000 hectares of agricultural land is being considered for no-till production, which may generate emissions reductions of over 1 $MtCO_2e$ per year. The expansion of activities in this field would be dramatically enhanced if carbon pricing mechanisms were available for Russian farmers. The total sowing land area in the country exceeds 116 million hectares (Ministry of Agriculture 2020).

WILL RUSSIA BE ABLE TO UTILISE ITS GREAT MITIGATION POTENTIAL?

Long-term targets for climate neutrality for the national economy have not been adopted in Russia so far. A draft of the country's strategy for decarbonisation by 2050 is due by October 2021. However, some research has been done by leading think tanks in recent years that may shed some light on the opportunities for deep decarbonisation in the country.

Modelling energy-related CO_2 emissions in key sectors of the Russian economy showed that fossil fuels will likely play a leading role in the domestic energy mix until 2030, but the situation will substantially change after 2030. Deep decarbonisation, with an 85% emissions reduction by 2050 (compared with current levels), would lead to an over 70% reduction in gas, oil and coal consumption, a boost in biofuel, solar and wind energy supplies, CCS use and more.

The mitigation costs depend on the policy ambition and decarbonisation targets. Under the adopted nationally determined contribution to the Paris Agreement, GHG emissions reductions will not incur any meaningful costs by 2030, but likely will thereafter (Safonov et al. 2020). Some external factors may speed up the process. For example, the EU Green Deal and its Carbon Border Adjustment Mechanism, as well as other international carbon regulations, will significantly affect Russian exports of fossil fuels and carbon-intensive products to the EU, Japan, Korea, China and North America, which have a carbon footprint of around 2.5 $BtCO_2e$ (as of 2020). Another incentive for active mitigation in Russia is shrinking the demand for fossil fuels. The latest modelling of international scenarios of deep decarbonisation provides that the role of natural gas as a bridge into a new energy future will be short-lived. In the most ambitious scenarios, the demand for gas may decline in the EU by 22%, in China by 12% and in Japan by 28% by 2030 compared to current levels.[4]

Russia's potential in climate change mitigation is large, but to tap it will require unprecedented actions. For now, the top governmental priorities include forest carbon sinks and hydrogen production, mostly due to expected low costs, high visibility and political motivation. The expansion of renewables, energy efficiency improvement, methane leakage control and other sectoral measures require much more routine (i.e. boring) work on the ground and involve much less political hype and benefits, but can

4 https://data.ene.iiasa.ac.at/cd-links/#/workspaces

reduce large amounts of greenhouse gases cost effectively. What matters is the price. A high carbon price could catalyse the process and prompt Russia to play a breakthrough role in decarbonising the world economy and avoiding the dangers of climate change for all.

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CHAPTER 8

Low-hanging fruit in Australia's climate policy

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INTRODUCTION

With the election of President Biden in the US and the new urgency for a global commitment to net zero emissions by 2050, Australia's climate policy is at a critical turning point. Pressure is increasing from the international community, including key allies, to increase national ambition on climate change, specifically through the formal adoption of a national net zero emissions long-term target and a more substantial 2030 emissions reductions target. The scientific case outlined in a report by the Intergovernmental Panel on Climate Change (IPCC 2021) reinforces the urgency of concerted climate policy action.

Australia's emissions have fallen since 2005. This fall in emissions has primarily been due to lower accounted emissions from land use, land-use change, and forestry (LULUCF) in earlier years and ongoing adoption of renewable electricity generation that is increasingly market-driven rather than policy effort.

There are substantial opportunities for emissions reductions that could be achieved through even moderate policy efforts. This effort could be complemented by measures that facilitate and accelerate the transition to renewable energy driven by changing cost structures and productivity-enhancing investment in green public infrastructure. A national carbon pricing policy was implemented in 2012 and revoked in 2014. Australia's climate policy is currently limited to selective federal mechanisms and specific programs at the subnational level.

Moving to net zero emissions by 2050 in Australia will require a refocusing of the climate policy framework. The political narrative on climate policy has been focused on fears of economic costs and job losses. Still, the real economic issue is not the potential impacts of domestic emissions reduction policies. Instead, it is the fact that Australia relies significantly on exports of fossil fuels and fossil fuel-intensive goods, making Australia's exports vulnerable to other countries' emissions reduction policies (McKibbin 2015a, 2015b). The implication is that as a vital component of national climate policy, Australia should implement policies to minimise the structural adjustment costs that will inevitably be faced as the world moves towards net zero emissions by 2050. It should also maximise new export opportunities, whether in low-emissions commodities and zero-carbon energy, agricultural products, or services.

In this chapter, we first outline the current state of Australia's climate commitments and existing policies. We then summarise where policies will need to focus on getting on a trajectory to net zero emissions in Australia by 2050. In particular, we focus on the low-cost options or the 'low-hanging fruit' that will also allow a more substantial 2030 emissions target to be achieved.

We argue that what is needed is a policy mix that includes credible carbon pricing to encourage all Australian households and corporations to change their carbon use in production and consumption as part of a broader portfolio of policies. Such a pricing scheme could evolve from the existing Safeguards Mechanism. Other necessary policy elements include public investment to support and accelerate the transition of the electricity grid to 100% renewables, including widespread decentralisation of electricity generation, and a mixture of innovation support along with targeted regulatory standards and incentives in specific sectors and activities including transport, buildings, some industrial activities, and agriculture.

These policies would usefully be complemented by an effective green infrastructure programme to stimulate demand and raise productivity in the medium term, funded by issuing long-term government bonds at historically low interest rates. Infrastructure investment would both provide a demand stimulus over the next decade to offset the adjustment costs due to structural change in the economy (Bang et al. 2020, Jaumotte et al. 2021). Well-targeted infrastructure investment could generate a private sector productivity stimulus in future decades to offset the economic costs from emissions reduction programmes.

Alongside these policies, we argue for the need for a community-focused structural adjustment fund that would enable disproportionately impacted communities to adapt to the reality of the global transition to net zero emissions by 2050. We also argue that there needs to be policies to remove the impediments and support for the emergence of new export industries takes the place of coal and gas exports.

AUSTRALIA'S INTERNATIONAL CLIMATE COMMITMENT, EMISSIONS TRAJECTORY, AND EXISTING CLIMATE POLICIES

Australia's Nationally Determined Contribution (NDC) to the Paris Agreement includes a commitment to reduce emissions by 26–28% below 2005 emissions by 2030. Australia re-communicated the same target in 2020, outlining a 'technology-focused approach' to emissions reductions.[1] A net zero emissions target has been under discussion, but the federal government has not committed to this target. In contrast, all Australian states and territories have adopted net zero targets or made statements of intent to achieve net zero emissions. There is no long-term national strategy with transparent policies that will achieve such a substantial reduction in emissions. Long-term emissions strategies are essential for guiding policy and investment decisions (Jotzo et al. 2021).

Since Paris, no new commitments have been made. Australia re-communicated its NDC in 2020 and affirmed the original target, in contrast to other developed countries that have strengthened their 2030 commitments.

Emissions trajectory

Australia's emissions fell by 16% from 2005 to 2020 (Department of Industry, Science, Energy, and Resources 2020a). This aggregate reduction is almost entirely due to lower accounted emissions from LULUCF, in addition to reductions in electricity generation emissions (Figure 1). Emissions from transport, stationary energy use (especially fossil fuel combustion in industry), fugitive emissions, and industrial processes have all increased. Agricultural emissions have declined, but this mainly reflects inter-year variability rather than an underlying trend. Emissions from waste have fallen by a small amount.

LULUCF emissions stood at 91 $MtCO_2$-equivalent ($MtCO_2$-eq) in 2005, declined to zero by 2015, and in 2020 were negative 18 $MtCO_2$-eq. The net effect of 107 $MtCO_2$-eq amounts to 18% of Australia's national emissions in 2005 and can account for the majority of reductions required to achieve the existing Paris commitment.[2] The reasons for the turnaround in LULUCF emissions are (in order of magnitude of effect) reduced land clearing, increased carbon uptake in forests, and lower emissions from agricultural and other land.

The emissions reductions have primarily come about not as a result of purposeful national climate change policy but as a result of sub-national land-use policies, changes in agricultural practices, and changes in growing conditions of forests. Annual carbon sequestration in the LULUCF sector reached its peak in 2017; it is not expected to contribute to further large emissions reductions in future years. Policy mechanisms such as the federal government's Emissions Reductions Fund are merely likely to prevent a reversal to the sector being a net emitter.

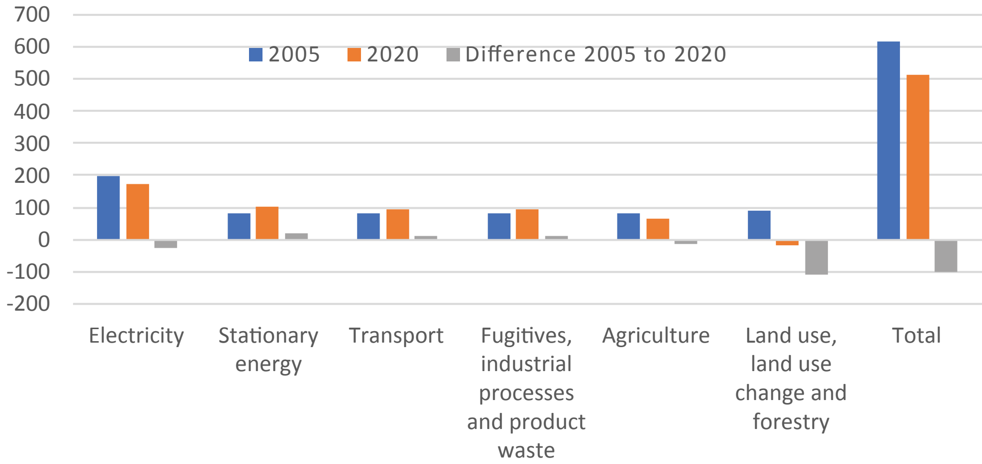
Electricity sector emissions peaked in 2016 and have since fallen by about 6 $MtCO_2$ per year or about 3% per year. This fall in emissions is because of the ongoing rapid expansion of solar and wind power, which mostly displaces electricity from coal-fired power plants.

1 www.industry.gov.au/policies-and-initiatives/australias-climate-change-strategies/international-climate-change-commitments

2 Australia accounts for its 2030 target as the cumulative emissions under a linear trajectory from a 2020 base to 2030, so the trajectory of emissions to 2030 also matters for target fulfilment.

Renewable energy is cheaper than any new form of fossil fuel based power generation, is increasingly supported by energy storage, and is expected to continue to replace coal-fired power in the Australian grid and increasingly also gas (AEMO 2021).

FIGURE 1 AUSTRALIA'S GHG EMISSIONS BY SECTOR, 2005 AND 2020 (MTCO2-EQ)



Data source: Department of Industry, Science, Energy, and Resources (2020a).

Renewable energy investment now happens primarily due to market forces rather than policy. However, some incentives remain for small-scale rooftop solar installations and some renewable power purchasing schemes by sub-national jurisdictions. Australia's future power system is likely to be primarily decarbonised even without climate change policy interventions because relative costs are in favour of renewable power. However, policy efforts could significantly speed up the process of coal plant retirements and investment in renewable energy supply, energy storage and grid expansion, and allow for an orderly transition process.

Existing policy mechanisms

The Australian federal government has several policy mechanisms to reduce emissions in particular activities and foster some low-emission technologies. As outlined by the Department of Industry, Science, Energy, and Resources (2020b), the main focus of the current Australian government is on encouraging the uptake of technology through lower prices for technology rather than increasing carbon prices.

A carbon tax in Australia was made politically impossible following a series of decisions on carbon pricing between 2009 and 2014. Both major political parties favoured a national emissions trading scheme between 2006 and 2009, when the then (conservative) opposition withdrew its support. A carbon pricing scheme – a permit scheme starting with a fixed price akin to a carbon tax – was introduced in 2012, only to be repealed in 2014 after a change in government. Following an adversarial political debate about climate change policy over many years, carbon taxes – or indeed any form of broad-based price on carbon emissions – remain politically profoundly unpopular. This resistance to carbon pricing is despite their proven effectiveness in reducing emissions (Best et al. 2020) and their demonstrated political feasibility in many other countries and sub-national jurisdictions.

Price-based alternatives to traditional carbon pricing such as emissions trading schemes or carbon taxes have been considered, prepared, and, to some extent, are in operation in Australia.

A core policy instrument in use since 2014 is the Emissions Reduction Fund (ERF). The ERF is designed to incentivise emissions reductions by providing funds for activities that reduce carbon emissions (Climate Change Authority 2017), mainly in land use, forestry, and agricultural activities. It consists of a crediting mechanism for project-based emissions reductions and a purchasing mechanism whereby the Australian government buys credited emissions reductions. Project proponents opt-in voluntarily and A$2.55 billion were initially allocated to the ERF. Contracted prices paid for emissions reductions were around A$12/t$CO_2$-eq by 2017, while the most recent ERF round paid an average of A$16/t$CO_2$-eq. A recent proposal is to expand the crediting and purchasing function to emissions reductions in industry.

The ERF suffers from the same fundamental problems as any opt-in project-based mechanism, namely, the tendency for adverse selection favouring activities as projects that may have happened anyway and the risk of overstating emissions savings relative to counterfactual baselines (Burke 2016). Elaborate systems aimed at assuring the integrity of emissions reductions cannot fully overcome these problems.

For the industry sector, a policy mechanism called the Safeguards Mechanism has been in place since 2016.[3] The mechanism covers around 200 industrial facilities with direct scope 1 emissions of greater than 100MtCO_2-eq per year. Companies must cover the excess of actual emissions over a counterfactual 'baseline' by purchasing emissions credits. However, to date the Safeguards Mechanism has been largely ineffective as baselines are in most cases higher than actual emissions, and have been adjusted upwards in some cases. During the 2019-20 reporting year, just 0.25 MtCO2-eq of excess emissions were covered through surrendered credits, compared to total emissions covered of 143 MtCO_2-eq.[4]

A national renewable portfolio standard, called the Renewable Energy Target, is in place in the electricity sector. However, the mandated amount of renewable energy has been largely fulfilled, and the price of renewable energy certificates from large-scale

3 www.industry.gov.au/regulations-and-standards/national-greenhouse-and-energy-reporting-scheme/safeguard-mechanism.

4 www.cleanenergyregulator.gov.au/NGER/National%20greenhouse%20and%20energy%20reporting%20data/safeguard-facility-reported-emissions/safeguard-facility-emissions-2019%E2%80%9320#2019-20-Reporting-year-summary

installations have fallen. Some sub-national jurisdictions have, at various points, tendered for the construction of new wind and solar using contract-for-difference instruments. Contracted prices in recent such tenders have generally been below contemporaneous wholesale market prices for electricity. Overall, there no longer is a significant subsidy element for new zero-emissions large-scale electricity generation investments.

No consequential policies exist to drive a shift to lower-emissions mobility in the transport sector, except for some limited preferential treatment of electric vehicles in some sub-national jurisdictions. There are no national minimum fuel efficiency or maximum emissions intensity standards for cars or other vehicles. Fuel taxes are low in international comparison, and no fuel taxation applies to agriculture, mining, aviation, and some parts of on-road transport.

The only significant policy mechanism to reduce emissions in agriculture is the ERF, providing subsidies to selected project-based activities.

LOW-COST POLICIES FOR MEDIUM-TERM EMISSIONS REDUCTIONS AND TOWARDS NET ZERO EMISSIONS

Several specific policies could be implemented in Australia that would help reduce emissions in specific sectors and activities individually. Collectively, they could amount to a portfolio that could reduce emissions significantly by 2030 and prepare the way towards net zero emissions by 2050.

These policies include pricing emissions in industry through a modification and broadening of the existing Safeguards Mechanism; investment in assisting the transformation of the electricity grid to very high shares of renewable energy; a community-focused structural adjustment fund that would enable disproportionately impacted communities to adapt to the reality of the global transition to net zero emissions by 2050; an effective green infrastructure programme to stimulate demand and raise productivity in the medium term; broad-based zero-emissions innovation support, along with targeted incentives and regulatory standards in specific sectors and activities; and removing impediments for the emergence of new export industries to take the place of coal and gas exports.

Carbon pricing in industry

The first element is a transparent mechanism to price carbon. A carbon tax or broad-based emissions trading scheme is seen as impossible at this point due to the political constraints discussed above. However, the Safeguards Mechanism could readily be turned into a price-based incentive to reduce emissions by large industrial producers. This transformation would be done by tightening baselines while at the same time issuing emissions credits to installations whose emissions remain below their baselines (Wood et al. 2021). This adjustment would turn the scheme into a baseline-and-credit system, where some emitters buy credits and others sell them, with potential linkages into the market for emissions credits under the ERF scheme.

Establishing such trading in industry could open the door to more comprehensive and potentially politically more durable carbon pricing arrangements.

Another option would be to establish the Climate Asset and Liability Mechanism (CALM) outlined by the Academy of Social Sciences in Australia (2020). This mechanism prices carbon annually out to 2050 through a hybrid approach of combining trading of long-term carbon certificates in fixed supply with a fixed short-term certificate price achieved by a climate bank intervening in the carbon market. The intervention is performed by the climate bank issuing additional carbon certificates that can only satisfy current year emissions. These certificates are sufficient to eliminate short-term price volatility in the carbon market along the transition path to a net zero target by 2050. This approach is similar to how monetary policy operates in many countries – a central bank fixes the short-term cost of money (the interest rate) but allows the long-term interest rate to be determined in the bond market.

In the context of the Safeguards Mechanism, this would mean allowing industrial emitters to use CALM permits to fulfill their obligations. The advantage of this approach is that households and firms are also allocated CALM assets that they trade in a market with firms that create carbon emission liabilities. The CALM system allows compensation to households and firms for higher energy prices and creates a sizeable political constituency that supports the continuation of the carbon pricing policy.

Facilitating the coal-to-renewables transition in electricity generation

A second area where low-cost intervention could speed up the climate transition is electricity generation. As outlined above, wind and solar power are already commercially competitive in Australia in that they are the cheapest option for new power generation investments. However, on average, coal-fired power generators still produce over 60% of the energy in Australia's primary electricity grid. Australia's grid would be able to be run on 100% renewable energy or close to it (AEMO 2021, ACOLA 2021) if substantial investments are made in new wind and solar generation assets and new transmission infrastructure and decentralised infrastructure and energy storage.

The outlines of a carbon-free Australian electricity supply system are evident, even with substantially larger total electricity use on the electrification of industry, transport, and buildings. Australia has practically unlimited potential for relatively low-cost solar and wind power and widespread sites for pumped-hydro energy storage (Blakers et al. 2017). An extensive government-owned pumped-hydro project is in preparation, and several commercial large-scale grid battery projects are in operation or preparation. Integrating electric vehicles into the grid will allow flexible, decentralised energy storage. A flexible demand-side response in industry and the building sector can lower the required total energy supply and storage capacity. Investment in decentralised smart grid infrastructure can also increase reliability and resilience against climate shocks such as extreme bush fires and floods.

However, the road to this outcome requires enormous investments, coordination between investors, and policies to smooth transitions from the existing to new patterns.

Structural adjustment in carbon-intensive regions

A third element of the policy package is to provide structural adjustment funding for regions within Australia that will be disproportionally impacted by the transition away from carbon-intensive activities. This structural transition assistance is a relatively low-cost investment at the current price of long-term debt. A key sticking point in the Australian political discourse is the relatively small number of affected regions with enormous political significance in a finely balanced political system. This significant cost potentially borne by particular communities has impeded implementing a national carbon plan.

Transition smoothing is needed for coal-fired power generators and the mines supplying them. The last closure of a major coal-fired power plant, the Hazelwood power station in 2017, shone the spotlight on local economic and social disruption (Wiseman et al. 2020). Such disruptions could be minimised through the planned, orderly closure of coal-fired power plants. Targeted approaches to facilitate coal plant closure, including possibly through market mechanisms (Jotzo and Mazouz 2015), would provide predictability and allow the acceleration of coal-fired power plant closures. To date, by contrast, concerns about energy supply security and the regional politics of job losses have tended towards policy interventions aimed to delay the closure of coal plants, thereby slowing the transition to a low-emissions power system.

A programme with substantial federal government funding would enable communities to make the inevitable adjustment to a low-carbon world. Dealing with regional structural adjustment and removing political roadblocks would allow the low-cost climate policies discussed above to be implemented with less political resistance.

Infrastructure investments

A fourth element is the need for government to provide infrastructure in a range of other areas that the private sector does not have the incentive to provide. Infrastructure investment has the advantage of providing a fiscal stimulus during the structural transition to a low-carbon economy and providing productivity benefits to the national economy, especially in times of low interest rates (Jaumotte et al. 2021).

Green infrastructure investments have been planned or implemented in many countries to counter pandemic-related economic slowdowns, under labels such as 'building back better' or 'green deal'. Options that are likely to yield both climate benefits and economic multipliers include clean physical infrastructure, building efficiency retrofits, investment in education and training, natural capital investment, and R&D into low-carbon technologies (Hepburn et al. 2020).

In Australia, there are many worthwhile infrastructure investments with prospects for a public good return that individual companies do not internalise and which would help the transition to net zero emissions. They could include electricity transmission infrastructure and smart energy networks, grid-integrated charging stations for electric vehicles, public transport infrastructure, and innovation support for new zero-carbon industries.

Innovation, incentives, and regulation in specific activities

A fifth element, comprising a wide range of specific policies and measures, is to support zero-emissions innovation, provide incentives for deployment of low-emissions technologies, and provide regulatory guardrails in specific activities where they are needed. These policies should be tailored to where broad-based policy instruments such as carbon pricing do not apply or are ineffective.

Support for applied, near-commercial R&D on renewable energy and related systems is provided by the Australian Renewable Energy Agency (ARENA). At the same time, the Clean Energy Finance Corporation (CEFC) is the government's green bank that supports first-of-a-kind low-emissions investments. The investment mandate of ARENA could be broadened to include other sectors and a broader range of R&D activities, and the magnitude of lending through the CEFC expanded.

Specific incentives for the uptake of zero-emissions technologies would be effective in transport, following the example of many countries that provide such incentives for early adoption of electric vehicles and in some applications in the building sector and agriculture beyond the project-based ERF mechanism. Regulatory action also has a role, including in the form of minimum efficiency standards for buildings, appliances, industrial machinery, and process standards in specific instances in industry and agriculture, to facilitate the phasing out of high emissions practices where affordable alternatives are available.

Supporting new clean energy export industries

Lastly, while Australia's comparative advantage in an unconstrained carbon world was partly based on fossil fuels, in a carbon-constrained world Australia's comparative advantage in energy will shift to its vast renewable energy resources, coupled with large amounts of available land. This new comparative advantage is associated with an open investment regime and institutional frameworks that support the emergence of new resource-based industries. This new comparative advantage provides scope for a large-scale renewable energy-based export industry such as hydrogen, ammonia, and green steel.

Currently, there are impediments to the emergence of these new industries. These impediments are dominated by the lack of an overall national climate policy framework coordinated with policies in the individual Australian states. There is a shortage of core physical and intellectual infrastructure and insufficient funding for research and development dedicated to future-proofing zero-carbon technologies, as distinct from those with remaining carbon emissions (Longden et al. 2021). There are also some market failures and regulatory burdens that should be addressed.

CONCLUSIONS

As an economy rich in fossil fuels, Australia faces economic and political hurdles on the road to net zero emissions that are magnified relative to many other advanced economies, primarily through reduced fossil fuel exports due to actions taken globally (McKibbin 2015a, 2015b, IMF 2020, Jaumotte et al. 2021, Fernando et al. 2021, Liu et al. 2020). At the same time, Australia has a strong emerging comparative advantage in renewable energy and ample opportunities to reduce national greenhouse gas emissions at a low cost. The country's current relative lack of ambition in international climate change commitments needs to be seen in this light.

The most efficient way to reduce greenhouse gases is to have a credible and rising carbon price to incentivise households and firms to change their behaviour and move away from carbon-emitting activities. Merely developing technologies, as is the focus of current Australian government policy, does not necessarily imply that technologies will be implemented. A carbon price signal can be established starting in Australia's industrial sector through the evolution of the existing 'safeguards' policy mechanisms and in a way that overcomes pervasive political hurdles to carbon pricing and that can help ensure political durability of carbon pricing.

An economy-wide portfolio of policies for cost-effective action on emissions also includes essential other elements. In electricity supply, which is at the core of economy-wide decarbonisation, policies should support the rapid transition to a 100% renewables-based electricity supply system, including decentralised energy provision and facilitating the exit of coal-fired generation assets. In other areas of the economy – including agriculture, transport, and buildings – a mix of more significant support for zero-emissions innovation, incentives for deployment of such technologies, and some minimum standards will help harvest the low-hanging fruit of emissions savings.

Investments need to be made to assist affected communities throughout Australia to transition to activities that replace high carbon-intensive activities. A green infrastructure programme would provide a demand stimulus in the coming decades and raise the return to private investments in implementing low fossil fuel technologies. With historically low interest rates, this transition and the infrastructure investment could be funded cheaply.

Together with efforts to remove impediments to the emergence of new, clean-energy based export industries, such investments can help overcome entrenched political resistance to the climate policies needed to get Australia on a trajectory to net zero emissions.

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CHAPTER 9

Climate policy opportunities for the United States

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INTRODUCTION

The US climate policy landscape has shifted fundamentally with the arrival of the Biden administration. President Biden's goals for the United States are to reduce net greenhouse gas (GHG) emissions 50% below 2005 levels by 2030, and to reach net zero emissions by 2050.[2] The policy path to achieve these targets is, however, not yet clear. At present, the United States has no national carbon pricing or other comprehensive climate policy in place. There exists a patchwork of sub-national policies, such as California's GHG emissions trading scheme, as well as sector-specific policies such as vehicle fuel economy standards. At the time of this writing, there are also sweeping efforts underway in the 117th Congress to bolster federal support for climate mitigation through policies ranging from funding electric vehicle charging stations to imposing methane emissions fees on oil and gas producers.[3] Whether all of these policies can be passed and how far they will go in reducing GHG emissions remains uncertain. The stakes are high as the United States is the world's second-largest emitter, responsible for approximately 13% of GHG emissions as of 2018.[4] Climate policy also remains politically challenging. While survey evidence suggests that public awareness of climate change has been increasing, misinformation remains widespread. According to recent estimates from the Yale Program on Climate Change Communication, only 57% of Americans believe that global warming is caused by human activities.[5]

Nonetheless, the present time presents an unprecedented opportunity for US climate policy. According to the Pew Research Center, the share of US survey respondents viewing climate change as a major threat has increased from 40% in 2014 to 59% in 2018 (Fagan and Huang 2019). In June 2021, a newly formed Conservative Climate Caucus in the US

1 I thank Kieran Walsh, Alexander Ludwig, and Rick van der Ploeg for insightful feedback on this chapter.
2 See the White House Fact Sheet of 22 April 2021 (available here).
3 See the White House Fact Sheet on Bipartisan Infrastructure, Investment, and Jobs Act, 2 August 2021 (available here. See also the Memorandum to Democratic Senators about the FY2022 Budget Resolution Agreement Framework (available here).
4 Percentage calculated from World Bank data on total greenhouse gas emissions by country (https://data.worldbank.org/indicator/EN.ATM.GHGT.KT.CE).
5 Source: Yale Program on Climate Change Communication website, figure pertaining to 2020 (https://climatecommunication.yale.edu/).

House of Representatives acknowledged the reality of anthropogenic climate change.[6] Many major US corporations have joined in supporting climate policy proposals such the bipartisan Climate Leadership Council's Carbon Dividend Plan.

This chapter begins by highlighting three core policies for an efficient US climate strategy: (1) national carbon pricing, (2) large-scale increases in clean technology R&D funding, and (3) climate risk disclosure requirements. The political feasibility of these policies is high for (2) and potentially also (3). For carbon pricing, there is now both support and opposition from both the right and the left.[7] This chapter argues that key concerns from both sides can be readily addressed through appropriate policy design. For example, carbon pricing need not add to Americans' tax burdens. In recognition of these political challenges, however, the chapter concludes with a brief discussion of (4) alternative policies. We highlight examples both of policies that may achieve emissions reductions at relatively low costs, such as a clean energy standard, and of policies that may not be cost-effective or could have unintended consequences, such as weatherisation assistance or restrictions on natural gas markets, showcasing the importance of evidence-based policy design.

POLICIES

National carbon pricing

There is a broad consensus among economists that carbon pricing is the most efficient and flexible policy tool to address climate change. A record number of more than 3,500 economists have signed the US Climate Leadership Council's "Economists' Statement on Carbon Dividends" to that effect.[8] Carbon pricing can 'get the job done', does so at the lowest economic cost, and raises revenues that can be used to lower other taxes, support low income populations, protect vulnerable industries, and enhance economic competitiveness. Recent studies illustrate the quantitative importance of these considerations for the US economy. For example, an analysis by the NERA Economic Consulting group found that a comprehensive national carbon price starting a modest level of $40 per tonne of CO_2 (2017 US dollars) could reduce US CO_2 emissions by around 50% by 2036 (NERA 2020).[9] Alternatively, the same emissions reductions could be achieved by a regulatory package including a federal clean energy standard for electricity generation, requirements for partial carbon capture and storage, increased energy efficiency targets for homes, buildings, and industrial processes, tightened vehicle fuel economy standards, electric vehicle battery market share targets, and a moratorium

6 See founding member Representative John Curtis' website at https://curtis.house.gov/conservative-climate-caucus/.

7 See, for example, a February 2021 Politico article, "Carbon tax chatter returns to shake up climate politics'', at www.politico.com/news/2021/02/16/carbon-tax-climate-politics-469138.

8 Source: Climate Leadership Council Website (https://clcouncil.org/economists-statement/).

9 The tax is assumed to rise at 5% per year in real terms and be accompanied by a border tax adjustment. A recent Stanford Energy Modeling Forum study comparing projections from 11 computable general equilibrium models of the US economy similarly found that a carbon price of $50 per tonne CO_2 in 2020 rising at 5% per year would decrease US emissions by 26-47% below 2005 levels by 2030 (Barron et al. 2018).

on fossil fuel extraction leases on federal land. Importantly, however, the carbon price achieves emissions reductions at significantly lower cost. By 2036, NERA estimates US GDP would be 1.5% higher and that annual per-household consumption would be around $1,000 higher with a carbon price compared to the regulatory package.

Another critical advantage of carbon pricing over regulatory approaches is that the revenues raised can be used to address concerns about the policy's broader impacts. First and foremost, carbon pricing need not add to Americans' tax burdens – every dollar raised can be returned to the economy.[10] This 'revenue recycling' can be structured to meet a variety of objectives. For example, Goulder and Hafstead (2018) find that negative profit impacts on the ten most vulnerable industries in the US can be neutralised (in present value terms) by allocating just 20–25% of revenues to adjustments such as targeted corporate income tax credits, tradeable carbon tax exemptions, or free permits in an emissions trading scheme. Potential impacts on low-income households can also be fully offset using only a fraction of revenues raised (Goulder and Hafstead 2018, Barron et al. 2018). Indeed, the perception of carbon pricing as necessarily regressive is outdated by new research (e.g. Metcalf 2019, Goulder et al. 2019). Lastly, carbon pricing revenues can also be used to improve economic efficiency by lowering other, distortionary tax rates, such as labour or capital income taxes. Some modellers have found that US GDP could be increased through such a 'tax swap' even in the absence of environmental benefits from climate policy (Barron et al. 2018). All 11 models of the US economy reviewed by a recent Stanford Energy Modeling Forum analysis found the gross costs of carbon pricing (ignoring environmental benefits) to the US economy to be modest, generally less than 1% of GDP (Barron et al. 2018). Finally, and perhaps most importantly, the potential net economic benefits to the US economy from carbon pricing are large. Even under an 'America first' policy of considering only domestic US climate and economic impacts, the net benefits of national carbon pricing tax swaps to the US economy have been estimated to range from hundreds of billions to trillions of dollars in present value (Barrage 2021), equivalent to around 1–10% of US GDP in 2020.[11] Economically speaking, a national carbon price – set at an appropriate level that seeks to balance costs and benefits – is thus a no brainer.[12]

Large-scale increases in clean technology innovation funding

Technological progress in low-carbon technologies is essential to solving the climate crisis in a prosperous and growing global economy. At present, incentives for such innovation are grossly insufficient due to both the lack of a clear global carbon price signal and due

10 Lack of trust in revenue-neutrality may be a concern (Carattini et al. 2018), but it can also be addressed. For example, British Columbia's carbon tax law prescribes a 15% salary reduction for the finance minister if revenues are not fully rebated (see www.bclaws.gov.bc.ca/civix/document/id/consol31/consol31/00_08040_01).

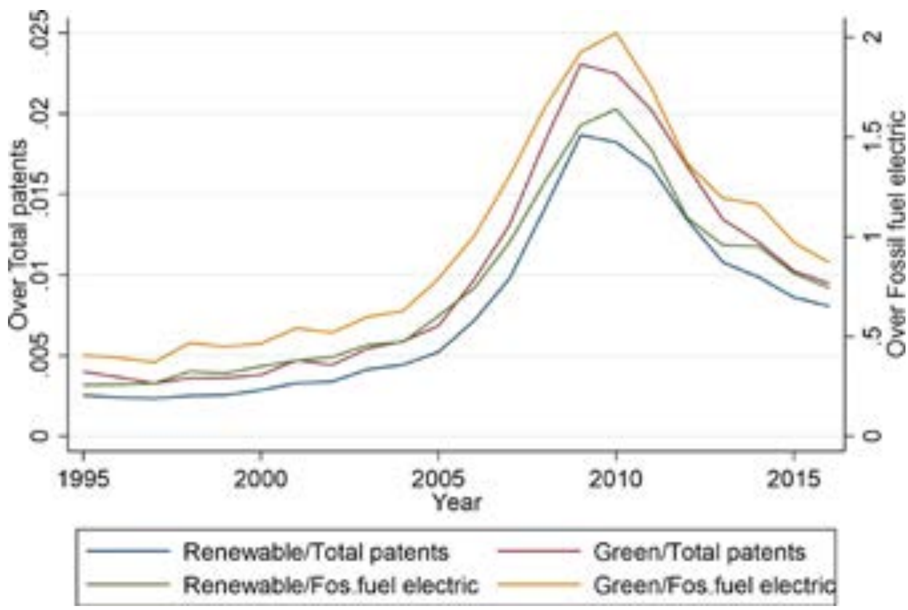
11 The high end of this range assumes that US emissions reductions yield partial positive spillover effects on global mitigation. Even without such a response, however, the US domestic benefits are estimated at up to around $500 billion, equivalent to 2.5% of US GDP in 2020.

12 For a more detailed discussion of these issues, see, for example, Metcalf (2018).

to insufficient fiscal support for innovation in clean technologies. For the United States in particular, massive increases in public support for research and development (R&D) in low-carbon technologies are a uniquely valuable and viable policy option.

First, they are urgently needed. During the past decade, the United States has seen a remarkable decline in many types of 'green' innovation. For example, after a steady increase for many years, the ratio of patents relating to 'green' versus fossil fuels-based electricity generation has fallen by over 50% since its peak in 2010, as illustrated in Figure 1 (Acemoglu et al. 2019).

FIGURE 1 US 'GREEN' PATENTING TRENDS



Source: Acemoglu et al. (2019).

While there are several potential causes, cheap fossil fuels, or more specifically the lack of a clear carbon price signal, and insufficient financial support for clean technology innovation unequivocally contribute to this trend. From 2009–2018, the US provided only around $4.8 billion per year on average in federal support for energy R&D through the Department of Energy, 20% of which went to fossil energy R&D (Clark 2018). Energy has accounted for only around 1% of federal R&D expenditures in recent decades (Dooley 2008). From an economic perspective, it is essential to provide public support to green innovation as it suffers from a double-externality: neither emissions reductions nor the societal rewards from innovation are appropriately priced by the market (e.g. Nordhaus 2021). Addressing climate change thus requires direct support for clean technology R&D along with a price on carbon (Acemoglu et al. 2012).

Second, increasing funding for energy sector technology and innovation is politically feasible. Survey evidence suggests high levels of support for such policies. For example, the Yale Program on Climate Change Communication estimates that 84% of Americans support research funding for renewable energy.[13] This support is well-founded, as past studies suggest high rates of return to public R&D investments (NAS 2007). Consequently, even in the politically charged environment that is the United States at the time of this writing, two notable recent examples of bi-partisan legislation provide new support for clean technologies.[14] The Infrastructure Investment and Jobs Act of 2021 includes significant support for clean hydrogen, advanced nuclear, direct carbon air capture, and other technology demonstration projects and regional research hubs.[15] The bill also provides funding for infrastructure such as electric vehicle charging stations, which – though not a subsidy to R&D – may still improve incentives for innovation by increasing the potential size of the electric vehicle market. The US Innovation and Competition Act similarly boosts funding for research on key technology focus areas, which include energy and efficiency technologies such as advanced nuclear and battery technologies, and anthropogenic disaster prevention.[16] Though limited in scope and size, both bills demonstrate that policies to enhance American innovation and technological leadership can earn bipartisan support.[17]

Finally, US clean innovation subsidies may be both strategically valuable and especially effective at reducing worldwide GHG emissions in a fragmented global policy context. That is, in a world where most countries are not yet pricing fossil fuels appropriately, any country that seeks to act unilaterally may face concerns over emissions leakage and trade impacts. In such a setting, clean innovation subsidies may be particularly effective as they can help reduce global emissions through technology spillovers or by helping maintain specialisation in key manufacturing sectors in countries headed towards a clean energy transition (e.g. Hemous 2016).

The United States has a long history of successfully moving the frontier in energy technologies. Institutions such as the Department of Energy and the national laboratories have successfully supported new technology development at all stages, from basic science to commercialisation through programmes ranging from research grants to public-private partnerships and loan guarantees (e.g. Pew Charitable Trust 2015). The United States is in a unique position to help meet the technological challenge of decarbonising the global economy, and to bolster its technological leadership role in the process. Increasing public funding toward this aim is thus a no brainer.

13 See the YPCC website at https://climatecommunication.yale.edu/visualizations-data/americans-climate-views.
14 At the time of this writing, both bills have passed in the Senate with bi-partisan support.
15 See the bill text at www.congress.gov/bill/117th-congress/house-bill/3684/text.
16 See bill text www.congress.gov/bill/117th-congress/senate-bill/1260/text.
17 Indeed, even the Conservative Climate Caucus in the US House of Representatives endorses the value of American innovation in energy technologies, although they are not endorsing specific policy proposals (e.g. https://curtis.house.gov/conservative-climate-caucus/).

Climate risk disclosures

Markets can only allocate resources efficiently if market participants are informed about the risks and potential returns of any given asset. Climate risk disclosures – pertaining to both physical and transition risks – are thus essential to ensuring efficient incentives for climate mitigation and adaptation. For example, investors seeking to reward firms for advanced technologies and lower carbon footprints need access to comparable, high-quality measures of such investments.[18]

Investors seeking to reduce exposure to physical risks likewise need information to steer their resources accordingly. These considerations are particularly important in the United States for at least two reasons. First, the United States is home to the world's largest financial market. For example, around 40% of the world's market capitalisation of listed domestic companies resides in the United States.[19] It also boasts one of the largest markets for investors seeking to invest in 'sustainable' assets (OECD 2020). Second, some empirical evidence suggests that US asset prices are not yet reflecting climate risks comprehensively, such as in the housing sector (e.g. Bakkensen and Barrage 2021, Baldauf et al. 2020, Murfin and Spiegel 2020, Hino and Burke 2020, Bernstein et al. 2019). Such mispricing may inhibit adaptation as, for example, housing development will not favour safer areas without a safety premium, all else equal. Importantly, however, emerging empirical evidence confirms that risk disclosure requirements can facilitate price corrections (e.g. Lee 2021, Pope 2008). Recent evidence has also linked disclosure requirements with CO_2 emissions reductions in the US power sector (Yang et al. 2021).

There is growing momentum across several G20 economies to develop harmonised climate risk disclosure frameworks. The United States expressed support for "moving towards" such disclosures at the G7 Meetings in June 2021 (BloombergNEF 2021). A bill directing the US Securities and Exchange Commission to require climate risk disclosures has also advanced in the US Congress in June 2021. The Federal Reserve is in the process of establishing a Financial Stability Climate Committee (Brainard 2021), and Chairman Jerome Powell recently signalled the possibility of climate stress testing in the future (Miller 2021). While the outlook for increasing climate risk information in the United States is thus currently favourable, much work remains to be done, including to ensure that all relevant sectors – such as housing – are eventually included. Information is the bedrock of a functioning free market. Ensuring the collection and dissemination of high-quality climate risk information is thus a no brainer.

18 While some private entities produce environmental, social, and governance (ESG) ratings, these scores diverge across providers (e.g. Berg et al. 2020). Firms can also provide their own signals of environmental performance, but such signals can be misleading (e.g. Barrage et al. 2020).

19 Figure pertains to 2019 (source: https://data.worldbank.org/indicator/CM.MKT.LCAP.CD).

ALTERNATIVE POLICIES

The policies outlined thus far would constitute a strong market-based climate policy portfolio. Unfortunately, however, national carbon pricing still faces political challenges. This section thus describes some alternative policies that may be adopted in lieu of carbon pricing.

One of the core advantages of a uniform carbon price is that it automatically provides appropriate incentives for emissions reductions across all relevant margins. Absent a carbon price, a suite of policies targeting different sectors may be required to achieve equivalent reductions, in line with current federal climate policy efforts. The final recommendation of this chapter is that such policy efforts be evidence-based. A growing body of research has produced important insights on the potential (cost)-effectiveness of a range of second-best climate policies (e.g. Gillingham and Stock 2018).

On the one hand, some policies stand out as attractive. For example, a federal clean energy standard for electricity generation can potentially achieve emissions reductions at a comparable or even slightly lower cost than a sectoral carbon price, depending on design features such as whether natural gas receives appropriate credits (Goulder et al. 2016, Goulder and Hafstead 2018). Given that the electricity sector is the most important and cost-effective decarbonisation opportunity in the United States (e.g. Barron et al. 2018), a national clean energy standard may thus be a highly valuable option. Current policy proposals also include several market-based instruments. For example, methane emissions fees imposed on oil and gas producers – as suggested by a bill introduced in the US Senate earlier this year – could internalise the social costs of said emission and increase economic efficiency if designed appropriately. Addressing methane leakage is especially important as the United States has become the world's largest producer of both oil and natural gas.[20] The United States also maintains some tax provisions favouring fossil fuel producers (e.g. CRS 2019). On efficiency grounds, removing fossil fuel subsidies is a no brainer, and President Biden has called for their elimination via Executive Order.[21] The quantitative significance of these tax provisions for US GHG emissions is, however, unclear.[22] Other recent price-based proposals include carbon border taxes (FY2022 Budget Resolution Agreement Framework) and climate royalty surcharges on fossil fuel extraction on federal lands (Prest and Stock 2021).

On the other hand, some policies may be less effective than previously thought. For example, large-scale experimental evidence has found that the US Weatherization Assistance Program - the largest residential energy efficiency programme in the US – fails to achieve the energy savings predicted by engineering models by a factor of 2.5 (Fowlie et al. 2018).

20 See the US Energy Information Administration International data hub at www.eia.gov/international/data/world.

21 See the Executive Order text at www.whitehouse.gov/briefing-room/presidential-actions/2021/01/27/executive-order-on-tackling-the-climate-crisis-at-home-and-abroad.

22 For example, a National Academy of Sciences report found that the percentage depletion allowance for oil and gas producers likely has only a very small impact on US greenhouse gas emissions (NRC 2013).

Some policies under debate, such as bans on US natural gas production or export, might even be counter-productive. The shale gas revolution, which increased the supply and decreased prices of natural gas in the United States, has enabled significant reductions in US carbon emissions by incentivising substitution away from coal-based electricity (e.g. Acemoglu et al. 2019). In some locations, natural gas also still plays an important role as a complement to intermittent renewable energy sources (Fell and Kaffine 2018). It is thus an open question whether such policies could produce net benefits, especially when the broader impacts, such as on local air pollutants and economic conditions, are considered.

A final caution about partial policies is that they must be created with care to avoid problematic interactions. For example, some prior research has found that hybrid vehicle subsidies such as from the 2005 Energy Policy Act may have had limited direct impacts on greenhouse gas emissions due to their interaction with vehicle fuel economy standards (Krupnick et al. 2010). Care must also be taken to consider potential interactions between state and federal policies (e.g. Goulder and Stavins 2011). In sum, however, while it will be difficult to replicate the full economic and environmental benefits of a uniform national carbon price, there are undoubtedly climate policy options that can yield substantial net benefits to society.

CONCLUSION

The United States is facing is an unprecedented opportunity to enact a comprehensive national climate policy. Within days of taking office, President Biden issued an Executive Order outlining broad climate policy goals.[23] From the perspective of economics, the tried and true market-based approach yields clear no brainer policy recommendations: (1) a national price on carbon, (2) large-scale increases in public support for clean innovation, and (3) climate risk disclosure requirements. If designed properly, such a policy package could yield substantial benefits for the US economy. While political concerns remain around a carbon price, the fact is that many concerns from both the left and the right can be readily addressed. Proposals such as the US Climate Leadership Council's Carbon Dividend Plan have already earned broad support, including from former Republican and Democratic officials, from environmental organisations, and from major corporations ranging from AT&T to IBM and Proctor & Gamble.[24] There is also growing international momentum towards policy coordination, and recent proposals such as a carbon price minimum among G20 countries – analogous to the recently agreed upon corporate income tax minimum – could further mitigate competitiveness concerns. The challenge ahead is large. In 1962, John F. Kennedy motivated the US space programme and efforts to reach the moon by noting that: "Our leadership in science and in industry, our hopes

23 See the Executive Order text at www.whitehouse.gov/briefing-room/presidential-actions/2021/01/27/executive-order-on-tackling-the-climate-crisis-at-home-and-abroad/
24 See the Climate Leadership Council website at https://clcouncil.org/membership/.

for peace and security, our obligations to ourselves as well as others, all require us to make this effort."[25] If the United States can channel this sentiment into the climate challenge, it can no doubt reach extraordinary achievements.

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25 Source: NASA (https://er.jsc.nasa.gov/seh/ricetalk.htm).

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CHAPTER 10

Improving Canada's approach to mitigating carbon emissions

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INTRODUCTION

Canada has a comprehensive carbon mitigation policy architecture to drive down emissions towards its 2030 enhanced nationally determined contribution (NDC)[1] of reducing emissions by 40% to 45% below 2005 levels and its net zero ambitions beyond. A carbon price is applied to the majority of Canada's emissions, complemented by a broad mix of regulations that are in place to address carbon emissions from fuels and vehicles, including a clean fuel standard[2] and a ban on coal electricity and on the sale of emitting cars and light-duty vehicles[3] by 2035. There are also regulations to improve the efficiency of vehicles, equipment, and buildings, and to control methane from its oil and gas sector. Recent federal budgets have committed tens of billions of dollars to transform infrastructure, invest in innovation, and to provide subsidies for industry and households to transition to lower-emitting alternatives. A Net-Zero Emissions Accountability Act received royal assent in June 2021, establishing a process to develop legally binding five-year emission targets and to make federal climate action more accountable and transparent.

While several opportunities to improve the effectiveness of this mix of policies invariably exist, it is in carbon pricing where we focus our attention. Undoubtedly, a range of overlapping market failures must be addressed to pave the way for a low-carbon transition (Hepburn et al. 2020). However, quantifying optimal policies for addressing spillovers, barriers, and behavioural failures can be challenging (Fischer et al. forthcoming). Carbon pricing remains a cornerstone policy tool in its ability to incentivise a range of low-carbon behaviours. Furthermore, we can rely on some straightforward principles for improving the cost-effectiveness of incentive-based regulation (Goulder and Parry 2008). First, incentives (carbon prices) should be consistent across emitters to ensure that marginal

1 www.canada.ca/en/environment-climate-change/news/2021/04/canadas-enhanced-nationally-determined-contribution.html

2 https://gazette.gc.ca/rp-pr/p1/2020/2020-12-19/html/reg2-eng.html

3 www.canada.ca/en/transport-canada/news/2021/06/building-a-green-economy-government-of-canada-to-require-100-of-car-and-passenger-truck-sales-be-zero-emission-by-2035-in-canada.html?utm_source=All+Media&utm_campaign=913a53e3b1-EMAIL_CAMPAIGN_2018_11_20_05_31_COPY_01&utm_medium=email&utm_term=0_135bfb50a9-913a53e3b1-347706637

abatement costs are equalised, else costs can be saved by shifting some effort away from higher-cost towards lower-cost entities. Second, carbon cost signals should be passed through to ensure that consumers and entities along the value chain take those costs into account and avail themselves of opportunities to conserve or seek lower-carbon alternatives. Finally, carbon pricing should be adequate for the climate policy package to meet the emissions target without excessive reliance on more costly and prescriptive measures like subsidies and mandates that are better targeted toward other market failures.

Within carbon pricing in Canada, two areas of low-hanging fruit present themselves:

1. **Managing the aspect of shared jurisdiction between the federal, provincial, and territorial governments**. This involves making sure federal standards support both stringency and cost-effectiveness involves coordinating elements of the considerable patchwork of sub-national programmes that exist within the country.
2. **Improving the stringency of carbon pricing programmes focused on the emission-intensive and trade-exposed (EITE) heavy industry in including the oil and gas sector**. This aspect primarily involves aligning benchmarks within sectors and across jurisdictions, increasing average costs through decreasing free allocations or tightening benchmarks under output-based pricing, and developing the market data and foresight to track overall system performance.

The discussion below starts with an overview of Canada's carbon pricing programmes. It goes on to explore Canada's emissions profile and the disproportionate emissions from large industrial emitters, and then finally presents a series of policy recommendations to improve overall cost-effectiveness.

SHARED JURISDICTION: A PATCHWORK OF PRICES AND COVERAGE

Just five years ago, carbon pricing within Canada covered about 38% of its national emissions. In 2020, 78% of Canada's emissions were under a carbon price of CA$30 per tonne rising to $50 in 2022, with a proposal to raise it to $170 by 2030.[4] Given that Canada is a federation with shared jurisdiction over energy development and pollution control between the provinces, territories, and the federal government, a patchwork of carbon pricing systems has emerged. These systems arose given a historical lack of ambition by the federal government, prior to 2016, to impose a national carbon policy—and carbon pricing more specifically—on the provinces and territories. As a result, provinces and territories were free to implement carbon pricing or not. A few did: British Columbia

4 www.canada.ca/en/environment-climate-change/news/2020/12/a-healthy-environment-and-a-healthy-economy.html

imposed a carbon tax; Alberta created a tradable credit programme for large emitters; and Québec and Ontario instituted cap-and-trade programmes that linked to California's (although Ontario's was short lived and was cancelled after a change in government).

An important distinction to keep in mind is that this shared jurisdiction extends to the energy sector, with provinces controlling and regulating the electricity and onshore oil and gas sectors. In fact, mineral rights are owned by the provinces, except for those on Aboriginal and federal lands. Practically, this means that the federal government has limited authority to regulate existing oil and gas operations or new project development in the country. Instead, the federal government is relegated to controlling some new project approvals through the environmental assessment process, to promoting energy efficiency, and to controlling the emission intensity of production.

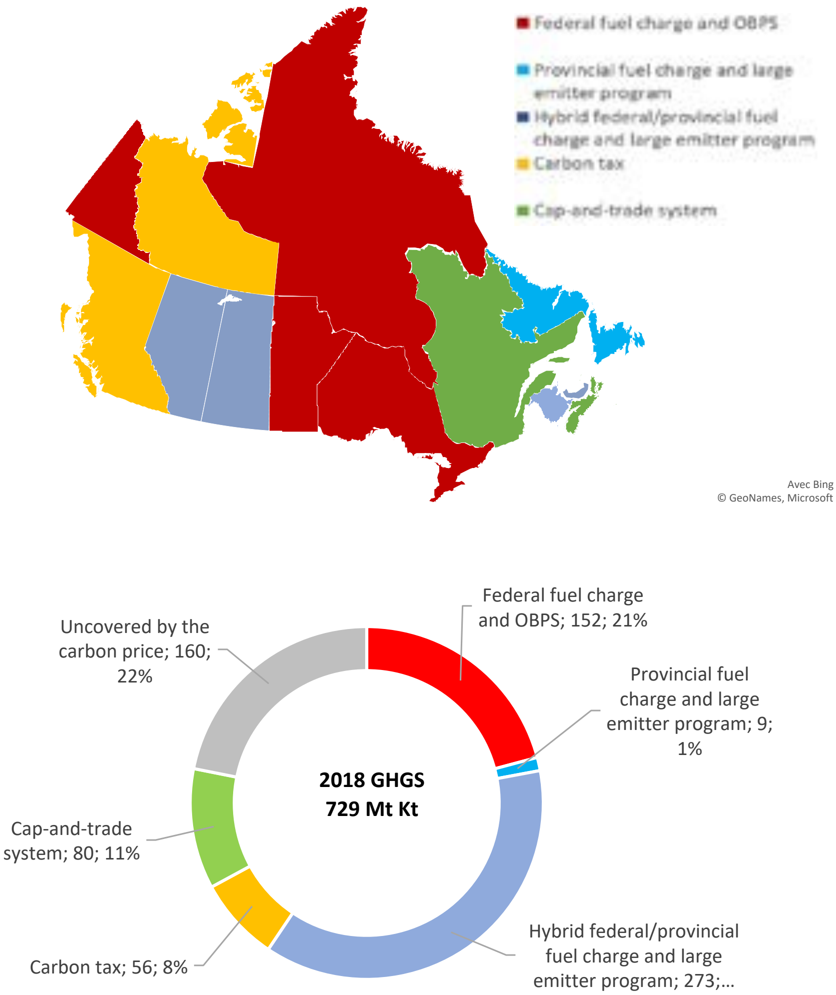
In 2016, the newly elected federal government developed, in consultation with the provinces, territories, and some national indigenous representatives, the Pan-Canadian Framework on Clean Growth and Climate Change (PCF).[5] The PCF is a national plan to coordinate federal, provincial, and territorial action on climate policy. Flowing from the PCF is the federal carbon pricing backstop,[6] which both recognised price and quantity-based carbon pricing systems in existence within the country but also required all other provinces and territories to either develop their own carbon pricing system that met a minimum standard; otherwise the federal government would impose its own backstop carbon pricing programme. Commencing in 2020, the federal government created a carbon tax and large emitter industrial carbon pricing program under the Greenhouse Gas Pollution Pricing Act, 2018 (GGPPA).

Canada now has a patchwork of carbon pricing policies that have been implemented that include provincial, territorial, and federal carbon taxes, cap and trade systems, and large emitter tradeable performance standards. Two parallel carbon pricing systems operate in each sub-national jurisdiction consisting of:

- covered liquid, solid, and gaseous fossil fuels with a price applied at the point of distribution, sale, or importation (nationally, fuels covered by the carbon price are 38% of total emissions); and
- a large emitter programme applied to emission-intensive and trade exposed heavy industry including, for example, electricity, oil and gas, cement, steel, chemicals, and fertilizers (nationally, large emitter carbon pricing programmes cover 40% of national emissions, of which the oil and gas sector constitutes more than half, or 21% of national emissions).

5 www.canada.ca/en/services/environment/weather/climatechange/pan-canadian-framework.html
6 www.canada.ca/en/revenue-agency/campaigns/pollution-pricing.html

FIGURE 1 CARBON PRICING PROGRAMMES OPERATING IN 2020



Notes: Five groups of carbon pricing programs are operating within the 13 sub-national jurisdictions, implemented as some combination of federal, provincial, and territorial programs: an economy-wide carbon tax (8% of emissions); two cap and trade systems (11% of emissions); a federal and provincial hybrid with the federal carbon tax covering liquid fuels and provincial industrial emitter programs (37% of emissions); a provincially administered carbon tax on fuels and an industrial emitter program (1% of emissions); and the federal backstop applied as a carbon tax on fuels and output-based pricing for large emitters (21%).

Source: Sawyer et al. (2021).

Five groups of carbon pricing of programmes are operating within the country, implemented by some combination of the federal, provincial, and territorial governments (Figure 1) (Sawyer et al. 2021). Not surprisingly, such a diverse mix of programmes has led to a very diverse set of design choices[7] that results in varying degrees of covered emissions and carbon prices across emissions:

7 https://climatechoices.ca/reports/the-state-of-carbon-pricing-in-canada/

- **Not all emissions that could be priced are priced**. On a levelised basis – where all jurisdictions are compared against a common coverage standard, accounting for certain emissions that are never directly priced by carbon pricing, such as land use emissions – the coverage across jurisdictions ranges between 69% and 97%.
- **Not all emissions see the same price**. Despite a federal benchmark of $30 per tonne, the marginal cost across jurisdictions ranges between $16 and $41 per tonne. Point-of-sale rebates, where provincial fuel taxes are lowered to offset the carbon price or the carbon price is rebated directly on the bill of sale, are a big determinant of the low marginal costs in some jurisdictions. Average costs also vary significantly, ranging from $4 to $36 per tonne. This divergence is primarily due to free allocations for large industrial emitters to protect competitiveness, but also to exemptions and rebates to protect some emitters from the financial impact of the carbon price.

These programme differences ultimately lead not only to threats to cost-effectiveness but also to very different distributional implications across sectors and jurisdictions.

LARGE EMITTER PROGRAMMES: VARIED COVERAGE AND PRICE SIGNALS

Emissions from large emitters covered by carbon pricing in Canada accounted for 40% of national emissions in 2020. In total, eight different large emitter programmes are operating within the country (Figure 2). All of these programmes make special accommodations for specified facilities or sectors that meet a certain emissions threshold or are deemed to be EITE.

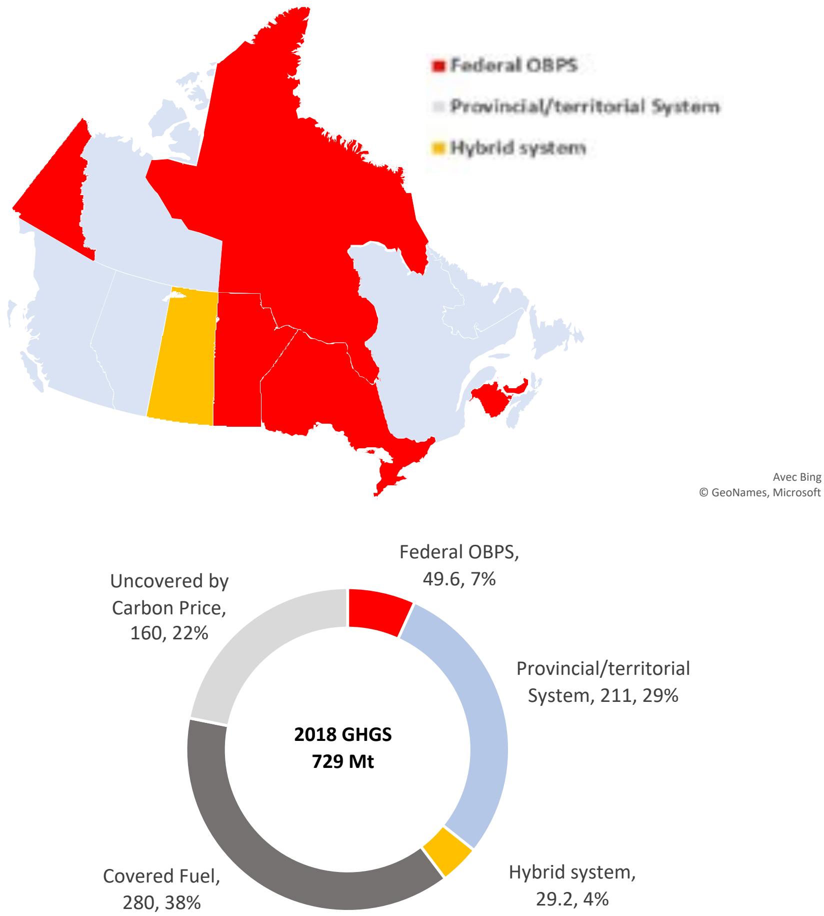
Of the covered large emitters, the oil and gas sector represents 21% of the national emissions total (or 28% of emissions covered by carbon pricing withing Canada); electricity is the second largest covered source of emissions, at 9% of the national total. All other large emitter sectors – such as cement, chemicals, iron and steel, and petroleum refining – are each in the range of 1% to 2.5% of total national emissions.

The large emitter programmes are designed to protect competitiveness through essentially granting free allocations either in cap-and-trade systems (as in Quebec and Nova Scotia) or through intensity-based benchmarks (as in the federal Output Based Pricing System (OBPS)[8] and Alberta's Technology Innovation and Emissions Reduction Regulation[9]). British Columbia applies a carbon tax to its large industrial emitters, with no free allocations. A defining feature of most of Canada's large emitter carbon pricing programmes (representing 34% of national emissions) is that they are intensity-based credit trading systems, with no hard cap on emissions. An emission intensity performance benchmark or standard is used to calculate the quantity of greenhouse gases (GHGs)

8 www.canada.ca/en/environment-climate-change/services/climate-change/pricing-pollution-how-it-will-work/output-based-pricing-system.html
9 www.alberta.ca/technology-innovation-and-emissions-reduction-regulation.aspx

owed (if emissions exceed the benchmark) or of credits available to sell (if the entity's emissions are lower). Typically, these credit trading systems pair a tradable performance standard with an alternative compliance mechanism being the fixed carbon price, which effectively limits the potential cost exposure for the firm. Compliance flexibility is further added through banking, trading, and the use of offsets.

FIGURE 2 CARBON PRICING FOR LARGE EMITTERS

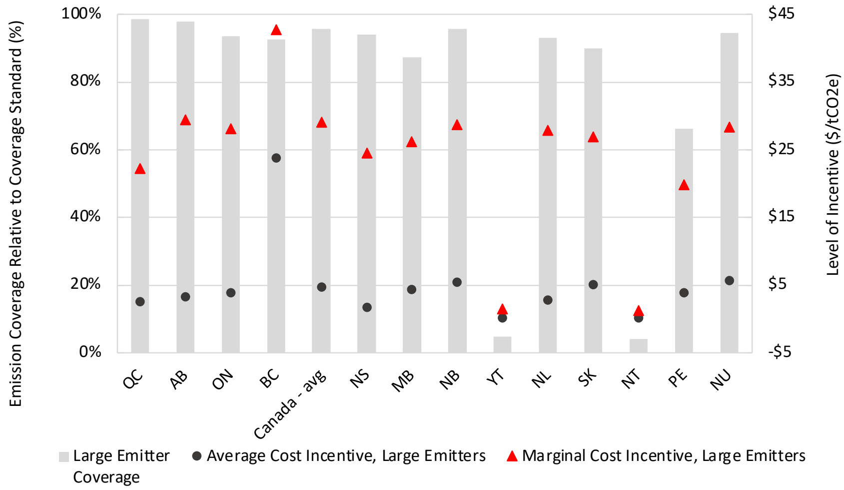


Notes: Eight different large emitter programs are operating within the country: the federal output-based pricing system in 6 jurisdictions (7% of emissions); 6 provincially operated programs (29% of emissions); and, one hybrid where the federal program covers some facilities and a provincially administered program covers other emitters (4%).

Source: Sawyer et al. (2021.)

Given the diverse mix of large emitter programmes, it is no surprise that the coverage and the marginal and average price signals vary significantly across these programmes (Figures 3 and 4). Such differences in the average cost indicate misaligned carbon costs within the country, implying a domestic competitiveness issue. But from an effectiveness perspective, such low average costs dilute the long-term price signal to invest in major facility retrofits or large abatement projects such as carbon capture utilisation and storage.

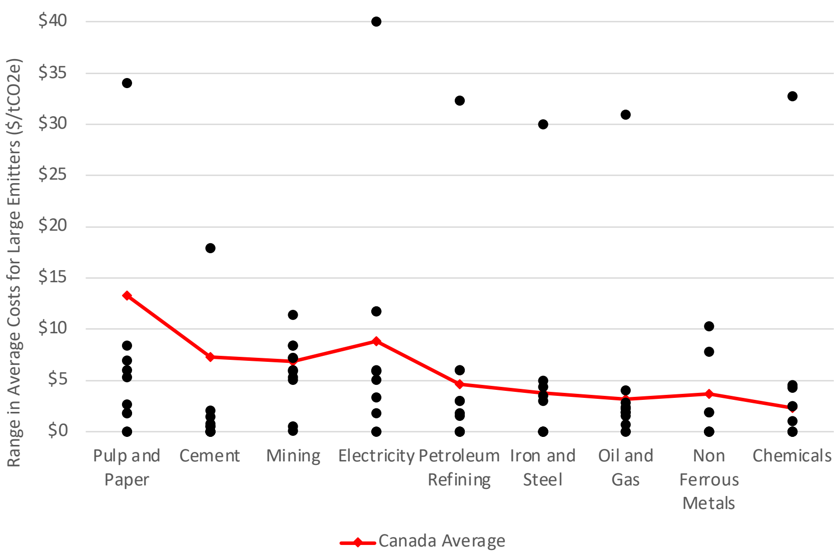
FIGURE 3 COSTS AND COVERAGE FOR LARGE REMITTERS



Notes: **Coverage is not uniform** (grey bars). Notably, process emissions are often included in the benchmarks while in some jurisdictions they are not covered by the carbon price. **Different marginal costs** (black dots). Differences in the marginal price can primarily be explained by the higher carbon tax level in British Columbia, the Western Climate Initiative allowance price in Quebec's cap and trade system, and Nova Scotia's price floor in its cap-and-trade program. **Average costs are very different between jurisdictions and within sectors** (red triangles). The biggest source of divergence includes the average cost within the programs, ranging between $2 and $26 per tonne with an average of $5 per tonne in 2020. This divergence is primarily a function of very different benchmarks (and thus stringency) across economic sectors as well as differing levels of emissions coverage.

Source: Sawyer et al. (2021.)

FIGURE 4 RANGE OF LARGE EMITTER AVERAGE COSTS ACROSS SECTORS AND JURISDICTIONS



Notes: The average carbon costs diverge within sectors and across jurisdictions, where the black dots are the average cost in each jurisdiction for each sector. These average costs are calculated as the share of compliance emissions to total facility emissions multiplied by the marginal cost in each jurisdiction. The red line is the Canadian average by sector.

Source: Sawyer et al. (2021).

LOW-HANGING FRUIT

Use the Net-Zero Emissions Accountability Act to better coordinate jurisdictional programmes. The PCF provides a forum for sub-national jurisdictions and the federal government to work more closely on coordinating climate policy within the country. The development of the new Net-zero Emissions Accountability Act provides an opportunity to coordinate the policy patchwork more formally. This multi-year process will require both incremental and wholesale changes in carbon pricing systems to ensure a more consistent application of the carbon price within the country.

Develop a standard of coverage for the consistent application of carbon pricing. As part of the federal carbon pricing policy benchmark, a standard of coverage should be developed for both covered fuels (households, transport, buildings, and businesses) and the large emitter programmes (EITEs). An approach that identifies emissions that are covered by the carbon price in at least one jurisdiction within Canada could be used to identify those emissions that could be covered by all programs under a coverage standard.

Remove carbon price rebates tied to fuel purchases. Several jurisdictions erode the marginal price signal through rebates tied directly to fuel use, including point-of-sale rebates that reduce the excise tax on fossil fuels. While the intent of the rebates is to reduce the financial impact of the carbon price on some households and businesses, there are other ways to address distributional concerns that do not erode the price signal. Notably, several jurisdictions return carbon pricing proceeds directly to households through the income tax system (as in the federal carbon tax rebate), reduce personal and corporate income taxes (as in the case of British Columbia), or use proceeds to subsidise low-carbon technology (such as the case of Quebec).

Align and ratchet down the large emitter benchmarks, especially for Canada's oil and gas sector. The very different average costs across the large emitters are symptomatic of a very different set of jurisdictional emission intensity benchmarks within and across sectors. This misalignment leads to domestic competitiveness issues where the misaligned average costs mean that some facilities within the country are at a competitive advantage over others. This also is a threat to cost-effectiveness where the low average-cost signal does not drive a consistent long-term signal that incentivises low-carbon investment choices in new capital projects and major industrial retrofits.

Ratcheting factors need to be built into the emission intensity benchmarks to reflect the transitional issues that the benchmarks are designed to address, namely, allowing firms the time to transition to lower emitter operations and accounting for the relative carbon prices of international competitors. As many of Canada's trading partners move to implement carbon pricing, the intensity benchmarks need to be adjusted.

As a first step, therefore, covered emissions under the benchmarks should be aligned within sectors and product groups for which the benchmarks are defined. Benchmarks then need to be aligned across jurisdictions within and across sectors, set to a best-in-class or top-performing level to ensure the benchmarks are sufficiently stringent to drive improved emissions performance. This would also ensure there is demand for credits in the intensity trading systems and that the carbon price is fully binding. Finally, ratcheting factors in the benchmarks needs to be added to signal that average carbon costs will rise in time at a rate more consistent with Canada's emission reduction goals.

This need for carbon cost alignment is particularly acute for Canada's oil and gas sector, where the average cost across jurisdictions is about $3 per tonne. Removing subsidies to the oil and gas sector would also send investment signals more consistent with Canada's long-term aspirations to reduce carbon emissions. Note that given the province and territories have jurisdiction over oil and gas development and operations, it is not possible for the federal government to simply ban new investment or halt oil production.

Take stock of market dynamics and review and tighten stringency as needed. With 40% of Canada's emissions covered by large emitters intensity trading programmes, risks to those systems mean the overall effectiveness of carbon pricing is at risk. In particular, overly generous benchmarks pose a risk to the functioning of the carbon market and its ability to support a carbon price on a par with that in other sectors. Since trading of compliance credits for large emitter programmes is private, prevailing credit prices may be difficult to observe, making it even more unclear whether the benchmarks are sufficiently stringent in the large industrial programmes to drive substantive emission reductions.

A priority for action is therefore to develop an informational standard across the jurisdictions that allows for the benchmarks to be assessed for their impact on stringency and market function. Routine stocktaking then needs to happen to assess whether the carbon price is binding, and marginal costs are at a level consistent with the posted carbon price. Foresight on compliance activity including banking and the level of supply and demand in the market is needed so that reviews can be conducted, and stringency assessed. Course corrections can then be implemented and investment expectations set based on certainty over the long-term stringency of the large emitter programmes.

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CHAPTER 11

Strategic decarbonisation options for the UK

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INTRODUCTION

Compared to other countries, the UK is in a good position when it comes to reducing greenhouse gas emissions. The country has a sophisticated governance framework centred around the 2008 Climate Change Act, which includes important aspects of good legislative practice that have subsequently been emulated by other countries (Averchenkova et al. 2021a).

The UK's long-term climate objective has been brought in line with the Paris Agreement with the adoption in 2019 of a net zero emissions target for 2050. Unlike in other anglophone countries, there is broad political consensus around this target. At the last general election in 2019, the manifestos of all major parties included net zero commitments.

The path to net zero consists of a series of statutory five-year carbon budgets, which are legislated 12 years ahead of time. They are recommended and monitored by a powerful independent body, the Climate Change Committee (CCC), which acts not just as a watchdog but also a trusted knowledge broker (Averchenkova et al. 2021b). The sixth carbon budget for the period 2033–37 was enacted in 2021 and mandates average emissions cuts over that five-year period of 78% relative to 1990 (Climate Change Committee 2021).

The first two carbon budgets for the period 2008–17 were met with relative ease and the UK is on track to meet the third budget for 2018–22. Between 1990 and 2019, economy-wide greenhouse gas emissions (excluding international aviation and shipping, which were outside the accounting framework until 2021) fell by 42%. Over the same period, UK GDP grew by about two thirds, implying a decrease in the carbon intensity of GDP of close to a factor three. In other words, the UK economy now requires three times less carbon than in 1990 to produce a pound sterling of economic output.

1 Funding from the UK Economic and Social Research Council through the Place-based Climate Action Network (Fankhauser) and the Centre for Climate Change Economics and Policy (Dietz) is gratefully acknowledged. We are also grateful to Josh Burke for his comments on an earlier draft.

This relatively favourable starting point, compared to other countries, does not mean the UK is well-prepared for the decarbonisation challenges that lie ahead, however. In fact, the UK is not on course to meet the much steeper and more difficult emissions cuts that the fourth, fifth and sixth carbon budgets will require in the 2020s and early 2030s (Climate Change Committee 2021).

In what follows, we briefly review the UK's emissions performance so far and sketch out the main measures needed to implement the legislated emissions path. We then highlight four strategic interventions that could help to unlock those changes. Thinking in terms of such sensitive interventions points, where a system can be nudged over a tipping point with reasonable effort (Farmer et al. 2019), offers a more strategic approach to decarbonisation than simply moving up a marginal abatement cost curve, and it recognises the system-wide nature of the required transformation. Hepburn et al. (2020a) offer a similar, but broader, set of potential intervention points.

UK DECARBONISATION PAST AND FUTURE

Many factors have contributed to the UK's relative success in reducing emissions, and not all of them have had much to do with deliberate climate policy. A rough estimate using global relationships between carbon intensity and climate policy suggests that 25 percentage points of the 42% emissions reduction observed between 1990 and 2019 were due to economic factors. Only 17 percentage points were induced by climate policy (Eskander and Fankhauser 2020, 2021).

Structural change toward an increasingly service-based economy has led to the decline of high-carbon industries, particularly during the early years of interest here. What heavy industry remains is increasingly focused on high-end products that are often less carbon intensive relative to value-added.

Arguably the most important driver of emission reductions was the energy market liberalisation of the 1990s. Together with Margaret Thatcher's dismantling of the coal unions, this triggered a 'dash for gas', which part-decarbonised the power system. Along with (European) air quality regulation, generous support for clean alternatives (contracts for difference for renewable energy providers) and a two-pronged carbon price (through the EU Emissions Trading System and a complementary carbon price underpin), it all but phased out coal from power generation (Green and Staffell 2021). Once the dominant fuel, coal now accounts for less than 5% of the generation mix. In the summer of 2021, the government ratified this trend by bringing forward the formal ban on coal-fired power generation to 2024 (HM Government 2021).

As such, the emissions cuts observed since 1990 are concentrated narrowly in just one sector – electric power. In most other sectors, emissions have flatlined. Surface and air transport emissions, in particular, remained stubbornly high, until falling precipitously and probably temporarily in 2020 as a consequence of the Covid-19 lockdowns. Surface transport is now the largest source of carbon emissions. Industrial emissions have fallen somewhat due to structural change, while waste emissions responded to a substantial tax that discourages landfilling. Buildings' emissions and agricultural emissions have barely moved for the past decade (Climate Change Committee 2021).

The progress in power sector decarbonisation is important. A cleaned-up power sector is at the core of Britain's decarbonisation strategy (Fankhauser 2013). Clean electricity can be used to decarbonise other sectors, such as surface transport (through electric cars), buildings (through heat pumps) and perhaps industry (through direct electrification or the use of clean hydrogen, which is electro-intensive to produce). The UK's decarbonisation strategy therefore envisages a rapid ramping up of clean electricity production.

Energy efficiency measures in both buildings and industry are still essential to keep the growth in energy demand manageable and to reduce the short-term use of electricity before it is fully decarbonised. The UK's building stock is notoriously old and energy inefficient, decades of (often haphazard) policy intervention notwithstanding.

Outside energy, agricultural and land use emissions will come more strongly into focus, with interventions required both on the supply side (farm-level emissions) and the demand side (food waste and eating habits). Land use strategies are closely linked to wider concerns about nature preservation and environmental sustainability (Seddon et al. 2021). The relevant policies are in flux, following the UK's departure from the EU and its Common Agricultural Policy. The sector will also be an important source of carbon storage through accelerated afforestation and peatland restoration.

Table 1 recapitulates some of the key measures, all equally important, that will be required over the coming 15 years, as identified by the Climate Change Committee (2021). Realising them will require a portfolio of policy measures to address a range of market failures and behavioural barriers (Bowen and Fankhauser 2017). The rest of this chapter outlines some particularly strategic interventions and within those some policy 'no brainers'.

TABLE 1 KEY INTERVENTIONS FOR MEDIUM-TERM DECARBONISATION

Sector	CCC recommendation
Power generation	40 GW of offshore wind capacity by 2030 (four-fold increase)
	One new nuclear plant operational by 2030; one further plant by 2035
Transport	No new cars and vans with an internal combustion engine sold from 2032
	Stabilisation of air passenger demand at ca. 2019 levels through the 2020s
Buildings	415,000 heat pump installations per year by 2025, rising to 1.1 million installations per year by 2030
	Close to 700,000 loft insulations a year throughout the 2020s
Industry	30 TWh/year of low-carbon hydrogen by 2030
	22 MtCO_2/year captured and stored in 2030
Agriculture	33% reduction in food waste from 2020 by 2030
	20% reduction in meat consumption from 2020 by 2030
Land use	Afforestation of 30,000 hectares per year by 2025, rising to 50,000 hectares per year by 2035
	Peatland restoration of 67,000 ha/year from 2025
Waste	37% reduction in residual waste per capita from 2018 by 2030
	25% increase in household recycling rates from 2018 by 2030
Greenhouse gas removals	4.8 MtCO_2/year by 2030 (primarily through biomass energy with carbon capture and storage, or BECCS)

Source: Climate Change Committee (2021).

MAKING POLLUTERS PAY

While acknowledging the multiplicity of interventions needed, most economists and many policy experts put carbon pricing at the core of the climate policy mix. Pricing carbon, through either a tax or emissions trading, begins to internalise the climate change externality and makes polluters pay.

While the UK was part of the EU, its main way of pricing carbon was the EU Emissions Trading System. The EU ETS was complemented by two additional UK pricing schemes: the Climate Change Levy, a carbon-energy tax aimed broadly at business emissions outside the EU ETS; and the Carbon Price Support, a top-up tax on the EU allowance price introduced to bring the ETS price (which was then seen as too low) in line with the UK's decarbonisation ambitions.

Upon leaving the EU, the UK chose to set up its own emissions trading scheme, which by and large mirrors the design and scope of the EU ETS. While this ensured continuity, it left open the need for a broader-based carbon price and a more coherent carbon pricing landscape. The reform of carbon pricing must therefore remain a crucial aspect of Britain's decarbonisation strategy.

The current policy mix entails a mix of different taxes, subsidies and regulatory incentives, which create uneven (and sometimes counterproductive) incentives to cut emissions. Prominent examples, and obvious no brainers to address, include the way the tax system discriminates against building renovation (facing the full VAT rate) over new buildings (zero-rated), and clean electricity (which faces high charges, including the cost of renewable energy support) over natural gas (which is untaxed and in the case of residential use does not face the full VAT rate). It makes building renovation and the switch from gas boilers to electric heat pumps – two key planks of the UK's decarbonisation strategy (Table 1) – much less attractive. But carbon pricing gaps also prevail in aviation, agriculture and upstream oil and gas production, among other sectors (Energy Systems Catapult 2020).

PROMOTING ZERO-CARBON INVESTMENT

Implementing the decarbonisation plan sketched out in Table 1 requires sustained investment in the order of £50 billion a year by 2030, about five times current levels (Climate Change Committee 2021). These high capital needs should not be confused with high economic costs. Over the economic life of the investments, the high upfront costs are counterbalanced by notably lower operating costs. Electric vehicles, for example, are still expensive to buy, but very cheap to run. The same holds for renewable energy sources, which have very low operating costs compared to gas-fired power generation.

The upfront capital nevertheless needs to be provided and facilitating access to zero-carbon finance is thus an important part of Britain's decarbonisation strategy and another no brainer. Lenders and investors are becoming increasingly comfortable with zero-carbon finance. Indeed, many see it as an opportunity for Britain's financial sector.

Public policy is still important to aid this process. In particular, the financial sector is expecting the government to provide more certainty about the policy environment within which climate investment takes place. The time inconsistency of climate commitments is a well-recognised risk (Hovi et al. 2009), and UK investors have been spooked in the past by the government's readiness to chop and change the rules (Averchenkova et al. 2021a). Most financiers would prefer government assurances to be contractual (as they are in renewable energy contracts), but more certainty can also be provided legally (in the way policies are written and enacted) and institutionally (the way they are implemented and enforced).

Another intervention where no brainers might be found is financial regulation. Financial regulators are in a powerful position to promote zero-carbon finance and enforce the adequate pricing of climate risks (Dikau and Volz 2018). Adjustments in regulatory requirements – for example, in the way climate risks are reported – would help financial institutions to better understand and manage climate-related risks and opportunities. Encouragingly, regard for the country's statutory net zero target has now been written into the remit of the Bank of England's Monetary Policy and Financial Policy committees (Bank of England 2021).

Public spending itself can make a difference and is best seen in the context of post-Covid economic stimulus spending (Hepburn et al. 2020b). In the UK, economic support through the pandemic has been focused on preserving economic activity through furlough schemes, business interruption loans and temporary tax cuts (IMF 2021). Targeted green spending in the style of the US or EU green deals has been less in evidence and could be a further no brainer.

There are expectations that this may change with the establishment of the new UK Infrastructure Bank, which was launched in an interim form in June 2021. Zero-carbon finance in the form of debt, equity or guarantees is central to the new bank's mandate.

BUILDING ZERO-CARBON SKILLS

There is no evidence that a zero-carbon economy is detrimental to employment. Indeed, the UK Government is hoping to create 2 million 'green' jobs by 2030 (HM Government 2020). However, the distinction between zero-carbon and conventional jobs will progressively lose meaning as the economy gets decarbonised. In a fully decarbonised economy, all jobs are zero-carbon.

A more useful framing is to study the changing demand for skills. Even if green employment options are plentiful, the shift into new occupations may be associated with structural adjustment costs. Initial estimates, based on the extrapolation of US data, suggest that about 3 million UK jobs, or some 10% of the workforce, will require some reskilling. A further 3 million occupations, for example in electrical engineering, are expected to be in greater demand (Robins et al. 2019).

Green jobs tend to make more use of non-routine cognitive skills and require higher levels of formal education, work experience and training, but overall the skill sets can be acquired on the job (Bowen et al. 2018, Consoli et al. 2016).

Nevertheless, addressing emerging skill gaps proactively is an important step in supporting the zero-carbon transition and should be a no brainer. It removes potential delivery bottlenecks, enhances productivity, opens up new opportunities and ensures a smooth transition for workers. Substantial zero-carbon skill demands outside the traditional growth centres in the South-East of the country (Unsworth et al. 2020) suggest that green reskilling could also support the government's agenda of 'levelling up' economically disadvantaged regions.

Initial steps to engage with this agenda have been taken with the creation of the government's Green Jobs Task Force (HM Government 2020), but much more remains to be done.

LEVERAGING LOCAL CLIMATE ACTION

Climate policy in the UK is concentrated in the hands of the central government and the devolved administrations of Scotland, Wales and Northern Ireland. Relatively little power has been delegated to local councils, even though they control important implementation levers in areas such as planning, housing, waste and local transport. Local authority groups also argue that they enjoy the trust of local stakeholders and are better able to realise local co-benefits (ADEPT 2021).

In recent years, local councils and community groups have become increasingly active on climate change. A recent review speaks of "strong, vibrant and broad-based support for more climate action at the local level" (Howarth et al. 2021). Three out of four local councils have declared a climate emergency and two thirds of them have followed this up with a strengthened climate action plan. Many have experimented with participatory structures like climate assemblies, citizens' juries or climate commissions.

Some of this momentum has been lost during the pandemic, but there is also a sense that national government policy often hinders, rather than supports, climate action at the local level. Council budgets have been cut dramatically and central government support for local climate programmes has been intermittent (Howarth et al. 2021).

Policy experts have called for better coordination across governance levels, a clearer framework for delivery and more predictable long-term funding as ways to enhance the zero-carbon capacity of local councils and communities (Climate Change Committee 2020). Supporting climate action at the local level, while maintaining coordination, is our final no brainer.

CONCLUSIONS

The next decade in Britain's zero-carbon transition will be harder than the past ten years. The rate of decarbonisation, as set in the statutory carbon budgets, will have to be much faster. Many of the easier measures have been implemented and the focus will shift towards hard-to-abate emissions in sectors such as industry, agriculture and aviation.

On the positive side, the UK has a strong and tested governance framework, with statutory short-term and long-term targets that (currently) enjoy broad political support. It also has a detailed decarbonisation plan to implement those targets, proposed by the independent Climate Change Committee.

Although the government's own decarbonisation strategy is still under preparation, the key interventions that are now required are fairly clear. They include a significant expansion of renewable energy capacity, the phase out of petrol and diesel vehicles in the early 2030s, scaled up investment in the decarbonisation of buildings and industry, and the promotion of nature-based carbon storage solutions.

The plans are ambitious, but they have been assessed for their technical feasibility and economic viability. This chapter has outlined a number of strategic interventions, including some policy no brainers, that can aide their implementation. They include a stronger, broader and more even carbon price; the quintupling of zero-carbon investment; a focus on zero-carbon skills; and the leveraging of climate action at the local level.

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CHAPTER 12

The French case

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THE ELECTRICITY MIX IN FRANCE AND IN THE EU

One of the cheapest ways to reduce CO_2 emissions is to replace coal by natural gas in the electricity mix. Per kWh produced, natural gas emits less than half the quantity of CO2 emitted by coal. So, this substitution substantially reduces emissions without reducing electricity consumption. Because coal is more expensive than natural gas in the US thanks to the massive supply of shale gas, this substitution has been at work there even without a carbon price. This is good for the planet and it is good for the American people, also because of the local pollution generated when extracting and burning coal. In the EU, the situation is more complex because it is more expensive to produce electricity using natural gas than coal. However, this merit order is reversed as soon as the price of carbon crosses the 30–40 €/tCO_2 threshold, which it did late in 2020. Assuming the prohibition of subsidies to the coal industry in Europe, together with an upward revision of beliefs about future carbon prices, we should see a rapid elimination of coal within the EU in the next few years, as the UK experienced over the last decade thanks to the introduction of a specific carbon tax in its electricity sector. This transition out of coal will have a massive impact on emissions in Germany and Poland, for example.

Of course, natural gas is not the panacea, but it is a first step towards a full decarbonation of our economies. Phasing out natural gas will be more complex because it will be the last dispatchable technology in the electricity mix. In the absence of a low-cost technology for massive electricity storage (hydrogen, battery, etc.), and given the high social cost of making electricity demand more flexible, natural gas will remain key to equilibrate electricity supply and demand and to escape blackouts.

France finished its programme of investments in its second generation of nuclear power plants in the early 1990s. It now covers 75% of the electricity demand, the rest being covered by hydroelectricity, gas, wind and solar. Its last three coal power plants will be closed in 2022. This implies that its electricity mix is already almost completely decarbonised. In contrast to most other EU members (Sweden is another exception), France has no low-hanging fruit for decarbonisation in its electricity sector, which is usually the main reservoir of least-cost 'decarb' strategies currently available in Europe. The French marginal abatement cost (MAC) curve is probably much above the average EU MAC curve, where the least-cost abatement actions have been scrapped from the figure.

Therefore, imposing on France the same target as other EU members of a reduction in emissions by 55% in 2030 compared to 1990 is very likely to impose greater costs on French citizens. Moreover, using a single EU-ETS carbon price signal compatible with the common target of 55% will not be enough for France to achieve the same objective nationally. This raises two questions. One concerns the efficiency of the symmetric allocation of abatement efforts and burden sharing within Europe. The second concerns the supplemental actions France should implement to attain its target.

FRENCH CLIMATE POLITICS

Over the course of more than a year starting in November 2018, France faced the crisis of the 'yellow vests', which was triggered by the planned increase on 1 January 2019 of the carbon tax covering its transport and residential sectors from €44/tCO_2 to €55/tCO_2. This tax has been frozen at €44/tCO_2 since then, and a *Convention Citoyenne pour le Climat* (CCC), consisting of 150 randomly selected citizens, has been assembled to make proposals for a French climate policy compatible with the 40% reduction target for 2030, as prevailed at the time. This commission held monthly three-day sessions of heavy work from September 2019 to June 2020, examining possible actions and auditing various experts. It submitted its report (*Convention Citoyenne pour le Climat* 2020) to the government in July 2020. The report contains 150 recommendations, three of which immediately rejected by Emmanuel Macron. One of these is the reduction of the speed limit on highways from 130 km/h to 110 km/h. An earlier report from experts demonstrated in 2018 that this measure does not pass the cost-benefit test, given the combined limited benefits of the measure in terms of emissions and lives saved. Another reason was more political, as the decision in 2017 to reduce the speed limit from 90 km/h to 80 km/h on standard roads – this one passed the cost-benefit test given the high number of lives saved there – was another source of resentment of the yellow vests.

Other proposals from the CCC include the following:

- banning terrace heaters
- banning advertisements for carbon-intensive goods, such as SUVs
- banning airline connections between French cities that can be reached within four hours by train
- taxing the aviation industry proportionally to its carbon emissions
- improving the attractiveness of trains, bicycles and shared transportation systems, through specific subsidies and a stronger public support for train/bike/car-sharing infrastructure
- banning the most polluting cars from densely populated cities soon
- planning the phasing out of fossil fuel cars in Europe

- banning fuel and coal heat systems, together with energy-inefficient housing units, by 2030
- reinforcing subsidies for global thermal retrofitting of poorly insulated housing units, improving regulation (certification and labelling systems) of the energy efficiency market
- developing carbon accounting for all goods and services, and enlarging the scope of firms with climate reporting obligations
- compensating and retraining workers most affected by the transition
- imposing a carbon border adjustment mechanism
- reducing the tax deductibility of carbon-intensive transport expenses
- rebalancing truck freight to (more efficient) railways
- reforming the international pollution standards prevailing in the shipping industry
- promoting low-carbon labour organisations
- investing in the energy efficiency of public buildings
- reforming the EU Common Agricultural Policy to green the agricultural sector
- making the destruction of environmental assets a crime (‘*écocide*’).

Interestingly, nothing is said about the electricity sector, despite its central role in energy consumption. Globally, the CCC refused to consider a carbon pricing instrument. The only academic economist audited by the commission was Katheline Schubert, who was flatly rebuffed within two minutes of raising the possibility of using a price signal to align the myriad of private interests with the common good in the domain of climate change. Here also, the yellow vests movement was heavily felt. However, several CCC proposals are related to carbon pricing, such as imposing a tax on airline companies proportional to their emissions or a carbon border adjustment mechanism. On 23 June 2021, Olivier Blanchard and Jean Tirole submitted their report on *The Major Future Economic Challenges* to President Macron. The first chapter of the report (written by Mar Reguant and myself) is devoted to climate change. Its main recommendation is to complement an all-purpose carbon pricing mechanism (based on a reformed EU-ETS) with some sectoral policies (the cost per tCO2 saved of which is smaller than a pre-determined carbon value growing over time).

Which of the proposals of the CCC are ‘low-hanging fruit’ for abating CO_2 emissions remains to be identified. Approximately 50% of these proposals have been translated into a law project currently under discussion in Parliament, many of them being changed in the process against the will of furious CCC members. For example, the ban on domestic flights has been limited to those for which there is no train alternative under 2.5 hours rather than the four hours proposed by the CCC. Among the existing train lines, only the Bordeaux-Paris connection would be relevant. The socioeconomic evaluation of the policy remains to be done, in particular to take account of the risk of seeing French international travellers avoiding the constraint through hubs in London or Frankfurt, which would hurt the rent of the national airline company with no real environmental benefit.

COST PER TCO2 SAVED FOR VARIOUS CLIMATE POLICIES IN FRANCE

Because France enjoys almost carbon-free electricity, any move to electrify the economy has more environmental benefits than in most other EU countries. Let us explore, for example, the case of heat pumps for residential use.[1] Consider a housing unit currently heated with fuel oil, burning 2 cubic meters of fuel (or 20 MWh) annually costing €1,600. This system emits 6 tCO_2 per year. It can be replaced by an electric heat pump whose installation cost is €13,000, amortised at €1,200 per year. The pump consumes 8 MWh of carbon-free electricity, which costs €640 per year. In net, this action costs €240 per year to save 6 tCO_2. The cost per tCO_2 saved is thus €40 – clearly a low-hanging fruit! If the residential sector were to be integrated into the EU-ETS system, many French households would have a private interest in switching from fuel oil to a heat pump. This could be an important reservoir of low-cost decarbonation in the next few years for the country, given the necessity to do more than most other countries in all other sectors than electricity.

In this context, thermal retrofitting of housing units becomes a secondary matter from the viewpoint of climate change if their heating system is already decarbonised. Glachant et al. (2020) demonstrated that the existing public subsidies for thermal retrofitting in France have a high cost per tCO_2 saved, at around €350/tCO_2 on average. Despite this, France is increasing its subsidies to the sector, in particular through its post-Covid recovery plan.

The transportation sector accounts for around 40% of CO_2 emissions in France. This is thus a key sector for the French climate policy. However, a recent report from France Stratégie (previously the French Planning Agency) demonstrates the high cost to decarbonize this sector today (Criqui 2021). Switching from a combustion engine to a mid-sized electric sedan would cost €413/tCO_2 in 2020, €272/tCO_2 in 2025 and €199/tCO_2 in 2030, even when accounting for a reduction in the price of electric vehicles by 29% in the long run. There is no low-hanging fruit in this sector in France for the foreseeable future.

The French wind and solar electricity sectors are in a rather complex situation. Because the electricity mix is already almost fully decarbonsed, enlarging the market shares of solar and wind would imply a substitution mostly from nuclear electricity to these renewable electricity sources. This has no climate benefit. Despite this, these renewable sources of electricity have received generous subsidies over the years. For example, in 2010, the

1 I thank Henri Prévot for providing me with the technical elements of this discussion (see www.hprevot.fr/).

guaranteed price for 20 years of the feed-in tariff for residential photovoltaic panels was 60 cents/kWh, compared with the levelized cost of 5 cents for (second generation) nuclear kWh. If I generously assume that this French solar electricity comes as a substitute for the kWh of the EU electricity mix (which emitted 400 g of CO_2), I get a cost per tCO_2 saved of more than €1,300! Nowadays, the feed-in tariff for solar electricity has been reduced to around 20 cents/kWh, which still values the cost per tCO_2 saved at around €350. For offshore wind electricity, the French government recently committed on a guaranteed price of 15.5 cents/kWh in the Bay of Saint-Brieuc in Britany.

There has been a long-standing debate about the 'greenness' of nuclear electricity in France as well as in Europe. I will not enter into that debate, or its related EU taxonomy. I observe, however, that France is on the verge of starting the construction of a site (in Bures in the French Ardennes) for the nuclear waste generated over the entire cycle of its second-generation nuclear power plant (from the 1970s to the 2040s). The cost estimated of this 'CIGEO' project (spread over 150 years) is €25 billion (undiscounted). This corresponds to less than 0.2 cents per kWh, a value far below the role that nuclear waste management plays in the public debate. The Blanchard-Tirole report supports the recommendation to extend the lifetime of nuclear power plants as long as they remain safe. France should not make the same mistake as Germany on that front.

CONCLUSION

Among the myriad of possible actions to reduce emissions in the short run, which are the ones that minimise the total cost of the necessary energy transition? In France, the yellow vest movement reminds us that the concerns about, respectively, the 'end of the month' and the 'end of the world' are never far from each other. The social acceptability of our climate policies requires attaining the climate objective at the least cost to the economy. The last two decades in Europe demonstrate that we have failed to optimise our global climate policy, in particular by failing to measure the cost per tCO_2 saved of different micro-measures. We have implemented climate actions that cost more than €1,000 per tonne of CO_2 saved (such as feed-in tariffs for solar electricity), and at the same time we have kept alive our coal industry, the substitution of which by natural gas would cost our citizens less than €50 per tCO_2! Most politicians have preferred to implement high-cost policies whose costs were hidden from the public, such as feed-in tariffs for renewable electricity or generous subsidies for electric cars.

We are now entering an era where climate policies need to be massive, implying sizeable changes in our ways of life. In this context, it becomes even more important to start by cropping the low-hanging fruit of the energy transition. In France, this has already been done by eliminating fossil fuels from our electricity mix, an obvious large low-hanging fruit. The French marginal abatement cost curve thus lies above those of most other EU members. This suggests that France will have to make more expensive efforts, either by imposing an additional carbon price signal or through some more aggressive sectoral policies.

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CHAPTER 13

Enhancing climate mitigation policy in Germany

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International Monetary Fund

BACKGROUND

Germany has made substantial progress in reducing greenhouse gas (GHG) emissions. GHG emissions in 2019 were 36% below 1990 levels (Figure 1, top panel), with emissions from energy falling by 45%, industry by 34%, buildings by 42%, agriculture by 11%, and waste management by 76%. Transportation emissions remain roughly unchanged. Despite the steady reduction in GHG emissions, Germany will remain a large global emitter in absolute and per-capita terms without new, or tightening of existing, mitigation policies (Figure 1, bottom panel).

Germany's national emissions are aggregated with EU countries and submitted as a bloc under the United Nations Framework Convention on Climate Change, under which the EU has emissions reduction targets ('nationally determined contributions', or NDCs) as part of the Paris Agreement. In 2021, the EU enhanced its target to a reduction of GHGs by 55% reduction from 1990 levels by 2030, up from a previous target of a 40% reduction. This EU target is allocated to an EU-wide emissions trading scheme (EU ETS) and, for non-ETS sectors, to countries through the Effort Sharing Regulations (ESR), although these have yet to be updated to be in line with the enhanced target at the time of writing. EU countries separately have national commitments that reflect their EU allocations (but can be more ambitious).

In 2019, Germany adopted the Climate Change Act (CCA), setting targets of a 55% reduction in emissions from 1990 levels by 2030 and attaining net zero emissions by 2050. The CCA also sets specified, legally binding and progressively tightening aggregated and sectoral emissions targets for energy, industry, transport, buildings, agriculture, and other emissions (e.g. waste). Following a landmark ruling by its constitutional court,[2] the CCA was amended in late June 2021, further tightening emissions targets to a 65% reduction from 1990 levels by 2030, an 88% reduction by 2040, and net zero emissions by 2045. The revised CCA also sets an annual path of aggregate emissions through 2040

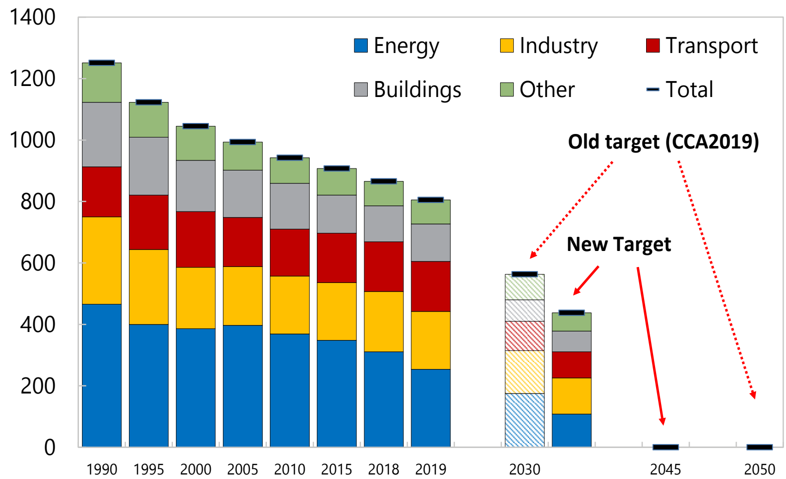
1 The findings, interpretations, and conclusions expressed in this chapter are entirely those of the authors. They do not necessarily represent the views of the International Monetary Fund, its Executive Directors, or the countries they represent.

2 www.bundesverfassungsgericht.de/SharedDocs/Pressemitteilungen/EN/2021/bvg21-031.html.

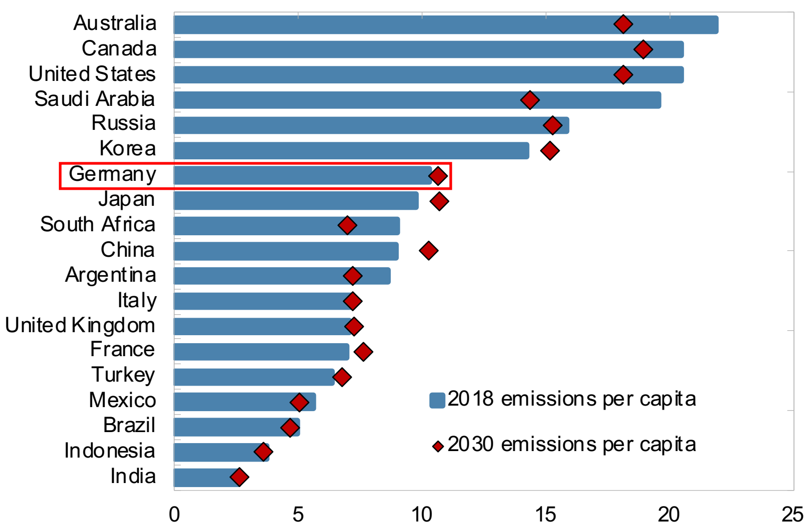
and revised annual sectoral targets through 2030.[3] To help curb emissions, the German government adopted the Climate Action Program 2030 (CAP2030) in 2019, setting out multi-pronged policy measures.

FIGURE 1 GERMANY'S TOTAL AND PER CAPITA GREENHOUSE GAS EMISSIONS

Germany: GHG emissions (millions of tonnes of CO2 equivalents)



Business as usual per capita GHG emissions, 2030



Sources: Federal Ministry for the Environment, Nature Conservation and Nuclear Safety.

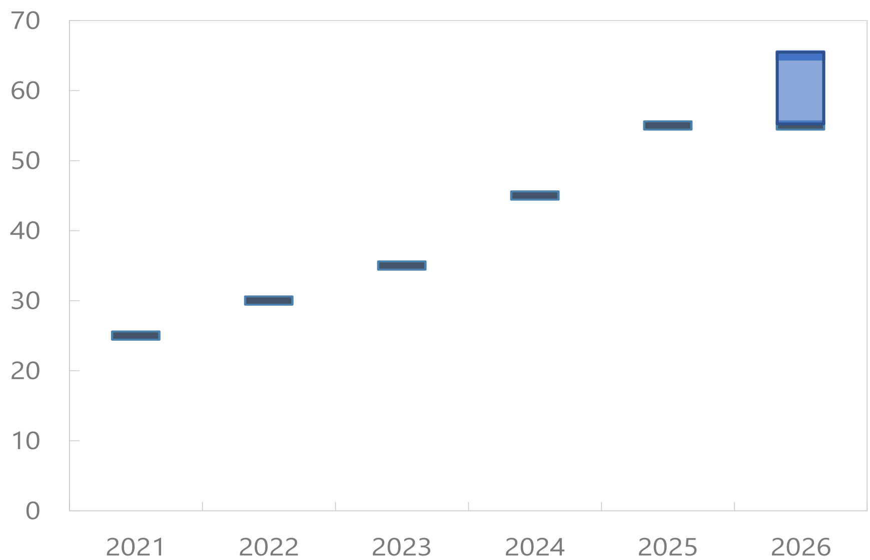
3 By 2032 at the latest, the government has to present a legislative proposal to set the annual reduction targets for the years 2041 to 2045.

The centrepiece of the CAP2030 is a national ETS, which was launched in January 2021. This complements the EU ETS, which covers the industry and energy sectors, and has the following features:

- **Coverage**: It covers the vast majority of Germany's remaining CO2 emissions from fossil fuel combustion (heating oil, LPG, natural gas, coal, gasoline, and diesel) that are not covered by the EU ETS, including from transportation and heating.
- **Prices**: From 2021–2025, fuel suppliers must purchase allowances from the government at a fixed price rising from €25 to €55 per tonne of CO2 (there is no cap on the amount of allowable emissions); in 2026 auctions will be introduced alongside a price collar of €55–65 per tonne of CO2 (Figure 2). Fom 2027 onwards, whether a price collar is retained is to be decided.
- **Caps**: From 2026 onwards, caps on allowable emissions will be introduced that will decline in line with Germany's emissions targets.
- **Revenue use**: Revenues from allowance sales are earmarked for climate measures (e.g. incentivising low-carbon transport, energy-efficient buildings, reduced renewable energy surcharge, higher communer allowance for long-distance commeters).

FIGURE 2 GERMANY: PLANNED CARBON PRICING

(€ per tonne of CO2)



Source: Germany's Climate Action Plan 2030.

The CAP2030 also includes a variery of other regulatory, pricing, and funding support, including:

- **Additional private sector incentives**: These include subsidies for wind and solar generation, for switching from coal to gas, and for retirement of coal plants;[4] enhanced incentives for electric vehicles (EVs) and relating annual circulation (vehicle) taxes to vehicle emission rates; incentives for energy-efficient refurbishment of buildings and phasing out of oil-based heating from 2026; and measures to encourage climate-friendly agriculture.
- **Public investment**: EV charging stations will be increased to one million by 2030, while public transportation will be promoted through lowering the VAT rate on train tickets (from 19% to 7%) and extra funding (around €1–2 billion per year) for transit infrastructure projects. The power grid network will be expanded in line with the expansion of renewable energy.
- **Research and development (R&D)**: Efforts include advancing carbon-saving technologies for industry (e.g. carbon capture and storage for cement production, use of electric rather than coal heating in steel production); battery cells for EVs; and laboratories for sector coupling (e.g. the Tesla Gigafactory).[5]
- **Just transition assistance**: Household and firm compensation for higher energy and consumer prices and €40 billion for developing new economic structures in the coal regions in North Rhine-Westphalia and central Germany through 2038.

POLICY OPTIONS FOR ENHANCING MITIGATION

Make cross-sector Carbon pricing Stronger and more predictable

Carbon pricing has several environmental, fiscal, economic, and administrative advantages over other mitigation instruments (e.g. Chen et al. 2020, IMF 2019a, 2019b, Pigato et al. 2019, PMR 2017, Stiglitz et al. 2017). It provides across-the-board incentives for firms and households to reduce energy consumption and shift to cleaner fuels. It also minimises mitigation costs by equalising the cost of the last tonne reduced across fuels and sectors, mobilises valuable revenues, and generates domestic environmental benefits (e.g. reductions in local air pollution mortality). Furthermore, carbon pricing can be administratively straightforward, at least for countries with mature institutional capacity. Thus, it is a no brainer to make cross-sector carbon pricing stronger and more predictable.

4 Following the Fukushima nuclear disaster in 2011, Germany has also decided to phase out all nuclear power by 2022. The case for revisiting nuclear power will depend on how costly it is to fully decarbonize power generation in Germany using renewables only.

5 Sector coupling involves the increased integration of energy end-use and supply sectors; electrifying energy demand while reinforcing the interaction between electricity supply and end-use.

The first-best carbon pricing strategy is to cover emissions comprehensively, establish predictable rising prices, align stringency with mitigation goals, and exploit fiscal opportunities. Fossil fuel emissions in Germany are comprehensively covered by the national and EU emissions trading schemes. However, Germany's current carbon pricing involves uncertainty beyond 2027, which may be a deterrent to investments in low-carbon technologies like renewables that have higher upfront costs but lower variable costs compared to high-carbon alternatives. For the power and industrial sector emissions, which are covered by the EU ETS, allowance prices have historically been volatile. Rising prices since 2018 largely reflect the introduction of the Market Stability Reserve (MSR) and the recently enhanced EU emissions targets, yet future prices remain uncertain. To make carbon pricing stronger and more predictable, the domestic ETS could incorporate an automatically escalating price floor after the expiration of the price collar in 2026.

Reduce cross-sector differences in marginal abatement costs

The responsiveness of emissions to carbon prices differs greatly across sectors (Table 1). The impact of carbon pricing on sectoral emissions depends on how it affects future energy prices and assumptions about the price responsiveness of fuel use and electricity.[6] We find that the national emissions targets for the power sector, which is covered by the EU ETS, could be met under a price of €100 per tonne of CO_2 in 2030. However, even a price of €150 per tonne of CO_2 appears to be inadequate to meet the targets for the transport and building sectors and is only just sufficient to achieve the target in industry. Prices consistent with emissions targets are much higher in the national than the EU ETS sector because emissions respond less to carbon price changes in the building and transportation sectors compared with power and industry. This primarily reflects the lower carbon-intensity of buildings and transportation. Price increases from higher carbon pricing – and thus higher fuel prices consumed (mosly liquid fuels and gas) – are more moderate in these sectors than price increases in the power and industrial sectors, which are more carbon intensive.

The great variation in the elasticity of emissions to carbon pricing across sectors suggests that reducing gaps in the marginal abatement cost across sectors could help cut aggregate emissions in an economically efficient way. Thus, it is a no brainer to apply higher carbon prices to sectors with a relatively low cost of abatement, such as power and industry.

At the EU level, extending the EU ETS so that aggregate emissions from power, industry, transport, and buildings are subject to one aggregate cap with a common emissions price across all sectors would lead to a more cost-effective balance of emissions reductions across sectors. This would, however, require compensation for (lower-income) member states with relatively less stringent targets under the current effort-sharing mechanism.

6 In IMF staff modelling, these assumptions are based on results from the modelling literature and econometric studies of fuel price elasticities.

TABLE 1 SECTORAL EMISSIONS OUTCOMES, 2030

	Percent emissions reductions below BAU						
Sector	Target	Carbon price					
		25	50	75	100	125	150
Power (electricity)	47	23	31	44	**49**	**54**	**57**
Industry	36	12	18	23	27	30	**38**
Power + industry	42	22	31	36	40	**43**	**51**
Transport	42	4	7	10	13	15	21
Buildings	24	3	6	10	13	16	19
Transport + buildings	35	3	7	10	13	15	21
Whole sector	44	16	23	28	33	36	42

Note: Bold cell entry indicates a price meeting an emissions target.
Source: IMF staff.

An alternative reform would be to allow member states to re-allocate emissions reductions from the transport/buildings sectors to the power/industry sectors. This would lower mitigation costs at the national level, given the much higher cost of incremental abatement in the former sectors implied by the emissions targets. Such a reallocation, however, is currently precluded by EU burden-sharing rules.

Another EU-level reform would be to establish an exogenous and escalating price floor for the EU ETS.[7] Besides providing a critical signal for ensuring that new investment is efficiently allocated to clean technologies, this reform would also allow overlapping measures at the member state level to lower emissions at the EU level (under a pure EU cap these measures only lower allowance prices without affecting EU emissions). Germany could push for a robust price floor under the EU ETS through reform of the Market Stability Reserve (MSR).

In the absence of broader EU reforms, imposing a domestic surcharge on emissions covered by the EU ETS could ensure robust carbon pricing in Germany. The surcharge could be set such that the (combined) price on power/industrial emissions equals a price target that ramps up predictably over time (ideally in line with prices in the national ETS). The surcharge would resemble the UK Carbon Price Floor, which imposes a national-level variable tax (set for three years in advance) on power sector emissions equal to the

7 There is some uncertainty over the legality of an EU level price floor if it is viewed as a fiscal (general revenue-raising) instrument rather than an instrument to support an environmental regulation. Use of allowance auction revenue to support the low carbon transition may help to address this issue (e.g. Fischer et al. 2019).

difference between an exogenous target price and the projected EU ETS price (Hirst 2018). The Netherlands is also implementing a similar scheme for emisisons from the power (and waste) sectors where the planned target price will rise from €30 per tonne of CO2 in 2021 (which is non-binding at present) to €125 per tonne in 2030.

Introduce Feebates

Feebates – revenue-neutral tax subsidy schemes – are the fiscal analogue of more traditional regulations, such as performance standards based on emissions rates, which are usually enforced by environment or other line ministries. Feebates are a novel instrument as they would be applied by finance ministries.

Feebates are potentially more flexible and cost-effective than regulations since the latter are only economically cost-effective with extensive credit trading provisions across firms and time. At the same time, feebates can naturally complement and reinforce (rather than substitute for) existing regulations (e.g. by rewarding firms for going beyond standards). In addition, they do not require new data or administrative capacity relative to the existing emission rate programme. Thus, it is a no brainer to introduce feebates, complementing sectoral policies.

In principle, feebates can be applied to any sector, but they are commonly used for car emissions. In Germany, road vehicles account for almost 95% of transportation emissions, with nearly two-thirds of these emissions from passenger vehicles and the remainder from trucks and buses (BMU 2020: Figure 25.[8] As of 2020, about two-thirds of the 48 million passenger vehicles were powered by gasoline and one-third by diesel. EV sales picked up strongly in 2020 on the back of a temporary VAT cut and increased incentives for alternative fuel vehicles,[9] and the trend has continued into 2021 (Figure 3).

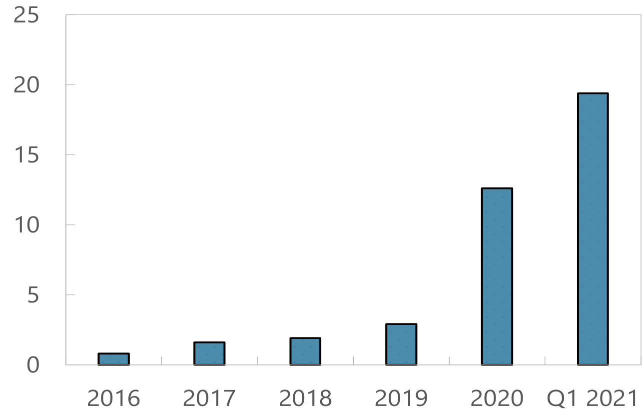
But decarbonising road transportation through carbon pricing (or higher road fuel taxes) alone is difficult due to the relatively modest impact it has on retail fuel prices and political resistance to higher road fuel prices (IEA 2019: 125-126). Partly as a result, clean vehicles are also promoted through regulations both at the EU and national level. By themselves, these standards would achieve roughly half of Germany's target emissions reductions for transportation in 2030, hence are not sufficient.[10]

8 The other 5% of transportation emissions are from domestic aviation, inland and coastal shipping, and rail.

9 The government provides the following purchase incentives ('innovation bonus') for new and used battery electric vehicles (BEVs), fuel-cell electric vehicles (FCEVs), and plug-in hybrid electric vehicles (PHEVs) through end-December 2021: for eligible cars with net list price of equal or less than €40,000, €9,000 for BEVs and FCEVs and €6,750 for PHEVs; for cars with net list price exceeding €40,000, €7,500 for BEVs and FCEVs and €5,625 for PHEVs.

10 This calculation assumes: current on-road emission rates are 20% above the current new vehicle standard; the average new vehicle purchased over the period has emission rate of 17.5% lower than the 2020 standard; 7.5% of the stock is replaced each year; and no change in vehicle km travelled. Broader reforms that could address other transportation externalities include (i) introducing charges on all passenger vehicle use related to km driven that vary with the prevailing degree of road congestion (i.e., charges per km would be higher for driving in congested conditions than non-congested conditions); and (ii) promoting a market-driven transition to pay-as-you-drive auto insurance.

FIGURE 3 GERMANY: SHARE OF EV SALES
(percent of total sales)



Source: S&P Global Ratings, ACEA.

Annual circulation taxes for passenger vehicles in Germany are also related to CO2 emission rates. As announced in September 2020, from 2021 onwards vehicles with emission rates below 100g CO_2/km will receive an annual subsidy of €30 while vehicles with emission rates above 100g CO_2/km will be subject to taxes that rise linearly up to €670 for a vehicle with emission rate of 300g CO_2/km. In addtion, EV buyers receive a subsidy of up to €9,000 and hybrids €5,625. Unlike in most other European countries, internal combustion engine (ICE) vehicles are not subject to registration fees.[11]

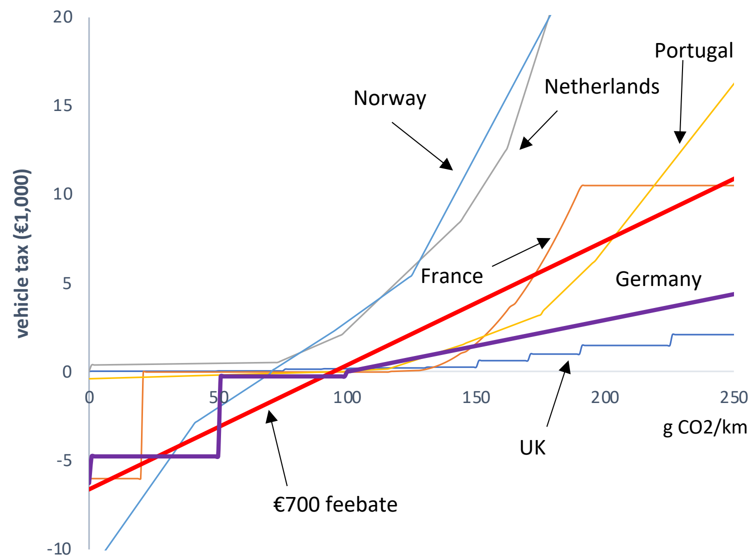
The existing tax system has limited effectiveness for two reasons. First, by expressing the circulation tax on a lifetime basis, Germany applies lower taxes for high emission vehicles than most other countries (Figure 4) – that is, it does less to drive a wedge between the price of high-emission and low-emission vehicles. Second, as the EU emission rate standards are applied to the fleetwide average emissions, any shift in demand to low-emission vehicles created by the tax system might be offset by less effort in reducing emission rates of other vehicles in the fleet.

A feebate applied to vehicle manufactures would address both problems. A feebate provides a sliding scale of fees on vehicles with above average emission rates and a sliding scale of rebates for vehicles with below average emission rates. Specifically, vehicle sales would be subject to an annual fee given by:

CO_2 price} x *{the vehicle's CO_2/km – the industry average Co_2/km}*
x *{the average lifetime km driven per vehicle}*

11 There is a one-time fee on initial vehicle registration, but this is only about €26. Vehicles are also subject to annual fees rising from €0 to €50 (gasoline vehicles) or €250 (diesel vehicles) for engine capacities of between 0 and 2,500 cubic cm. (ICCT 2018: 11-12).

FIGURE 4 CO_2-BASED COMPONENTS OF VEHICLE TAXES



Note: Feebates assume road fleet average emission rate of 115 g CO2/km. Circulation taxes for Germany are expressed on a lifetime basis assuming a 13-year life and 7% discount rate.
Source: ACEA (2018) and IMF staff calculations.

For illustration, a feebate with price of €700 per tonne of CO_2 would provide the same EV subsidy as at present, but would apply a tax of €7,400 to a vehicle with 200g CO_2/km (an increase of around €4,500). Subsidies for EVs would decline over time as the average fleet emission rate declines, which is appropriate as the cost differential between clean vehicles and their gasoline/diesel counterparts narrows over time (e.g. with improvements in EV battery technology). And manufactureres would be penalised for any increase in emissions for the rest of their fleet in response to higher sales shares for EVs. A feebate with a rising price that is sufficient to progressively shift the share of EVs in new vehicle sales to 100% by 2030 would reduce road fuel emissions 30% below otherwise projected levels for 2030.[12] Deeper reductions would continue after 2030 as the fleet continued to turn over.[13]

Scale up green infrastructure and support green innovation

There are a variety of market failures at different stages of the process of developing and deploying new emissions-saving technologies that warant public investment and technology policies (e.g. Arregui et al. 2020). Examples of such failures are those associated with knowledge spillovers in shifting to new technologies, warranting additional policies targeted to specific technologies. Public investment can also address

12 This calculation assumes 8% of the fleet is replaced each year (i.e., vehicle lifespans are 12 years) and initially 2% of new vehicle sales are EVs, rising linearly (due to the feebate) to 100% by 2035.
13 There is a key role for other complementary policies, for example, provision of EV charging infrastructure, procurement for EVs in public vehicle fleets.

network externalities associated with clean technology infrastructure (e.g. the reluctance of one electricity producer to extend the power grid if other producers can also benefit from it). Thus, it is a no brainer that scaling up green infrastructure and government spuuport for green innovation can facilitate a smooth green transition.

Increasing public support for R&D on green technologies and the deployment of new technologies would help address market failures and generate positive spillovers. The government should provide direct support for R&D on technologies that are not yet commercially viable but have considerable social benefits. For example, carbon capture and storage, smart grids, and batteries to store intermittent renewable power may be socially desirable but not financially attractive to private investors. Still, they can help reduce carbon emissions, improve the current power system's flexibility, and reduce the pressure on the existing grid system. Government support may also be needed when deploying new technology to promote learning-by-doing at one firm that can benefit other firms adopting the technology later. The production cost can be high at the early deployment stage of new technology and will fall as output increases, reflecting learning-by-doing. Government support should then be gradually phased out as technologies are widely adopted.

An upgraded infrastructure is needed to support the expansion of green energy supply and promote its usage. The largest share of renewable energy is from wind, generated mostly in Germany's north and north-east parts. To fully utilise this renewable power, the electricity grid needs to transport it to where it is currently needed, as well as where it would be needed in the future. Large metropolitan and industrial centers are primarily located in the south and west parts of the country. Current north-south transmission lines are facing bottlenecks and rising costs when transporting and stabilizing the power generated from volatile renewables even at current capacity.[14] Grid expansion should be prioritised in line with the Network Development Plan 2019–2030, which assesses where extra-high-voltage grids need to be expanded or upgraded over the next 10 to 15 years and defines appropriate expansion projects. In the transportation sector, sufficient rapid charging stations are necessary to encourage and enable the uptake of election vehicles. The government plans to increase public charging stations from the current 35,000 (which includes fewer than 3,000 fast charging units) to 1 million by 2035. Frontloading such investment could encourage speedier adoption of electric cars by addressing 'range anxiety' and crowd-in private investment to further expand the charging infrastructure.

14 Grid stabilisation means balancing the production and consumption of energy.

POLICY OPTIONS TO CUSHION THE IMPACT ON HOUSEHOLDS AND FIRMS

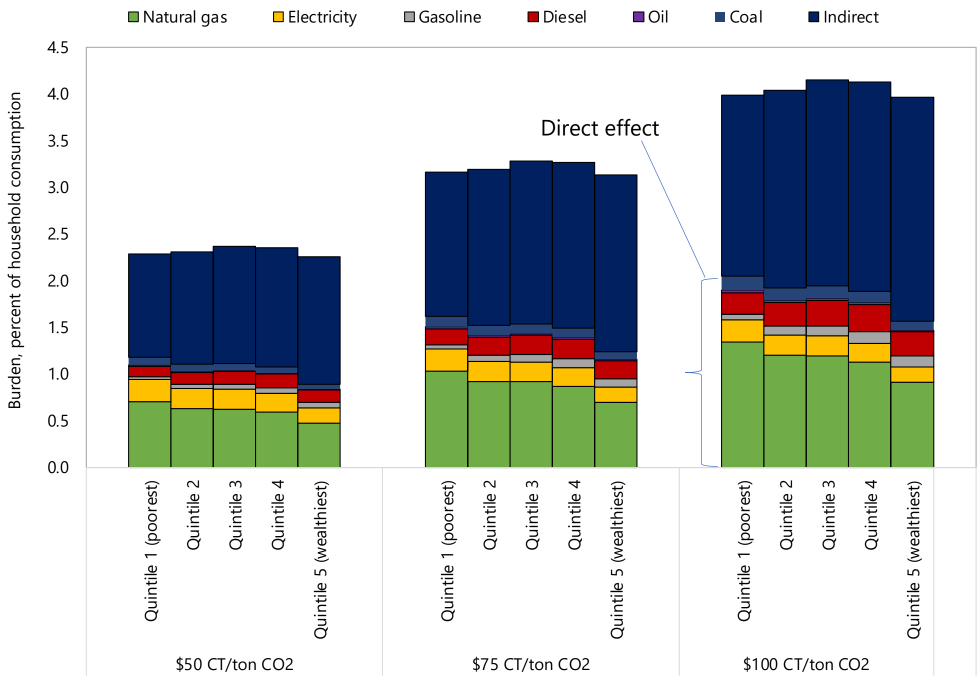
Households

Higher carbon prices affect households directly by raising the price of energy ('direct impact') and indirectly through driving up prices for consumption goods and services in general ('indirect impact'). An analysis of the incidence of raising the carbon price by \$50, \$75, and \$100 per tonne of CO_2 from existing prices by 2030 is conducted using consumption survey data by income quintile.[15] The calculation of the burden does not take into account the use of carbon price revenue, which could correct for any regressive impact.

The results suggest that the direct impact (i.e. the sum of impact from higher pricing of natural gas, electricity, gasoline, diesel, and oil) is moderately regressive, with an impact of 2% of consumption for the lowest income group compared to 1.6% of consumption for the highest income group under a carbon price of \$100 (Figure 5). However, the regressive impact is largely offset by the progressive indirect impact, making the overall impact broadly neutral.

FIGURE 5 GERMANY: CARBON PRICE BURDEN ON HOUSEHOLDS

(percent of total consumption, by household income quintile)



Sources: Eurostat LIS database, Haver Analytics and IMF staff calculations.

15 We are here assuming full pass-through of carbon pricing into consumer prices, adjusting for declines in energy consumption based on estimated elasticity and assumed changes in energy efficiency.

Compensating the lowest quintile fully for the effect of raising the carbon price by $100 per tonne would require revenues of 0.1% of GDP, which is substantially smaller than the estimated carbon revenue of 0.75% of GDP. The government has made it clear that all additional revenue from carbon pricing will be re-invested in climate action measures or returned to taxpayers, and the CAP2030 already contains several measures to mitigate the adverse impact on households. For example, the renewable energy surcharge is reduced, subsidies for long-distance commuters are increased,[16] and housing benefits are raised. Furthermore, there is additional budget support for refurbishing buildings to increase energy efficiency and making public transportation cheaper. A broader compensation mechanism could seek to reduce labour tax burden on lower-income households, which can also entail a positive effect on labour supply.

Firms

Countries may be concerned that increasing the stringency of their carbon pricing regimes would reduce industrial competitiveness and shift carbon-intensive production overseas leading to carbon leakage. Empirical literature mostly finds small impacts of carbon pricing on competitiveness (relative to other factors) or no evidence of carbon leakage, although sometimes this is attributed to the limited scope of carbon pricing schemes adopted during the period of investigation.[17] However, a recent study suggests higher leakage rates, with 22% in Germany (i.e. increased emissions abroad are 20% of the domestic emissions reductions due to carbon pricing), less than 15% in China, an EU14+UK aggregate, India, and Japan, and 7% in the US (Misch and Wingender 2021). And in practice there is heightened concern about competitiveness and leakage effects as countries move towards deeper decarbonisation of the industrial sector.

The EU plans to address the impact of higher energy prices on vulnerable firms through a border carbon adjustment (BCA)[18] slated for introduction in 2023. A BCA is a measure applied to traded products that seeks to make prices in destination markets consistent with the costs they would have incurred had they been subject to the destination market's carbon pricing regime (Cosbey et al. 2012). Under this scheme, importers pay an import tax or purchase emissions permits, while exporters might receive rebates for the impact of carbon pricing on their fuel and electricity inputs. A BCA of $120 per tonne applied to EITE industries at the EU level would have raised revenues by about 0.2% of GDP at the EU and German level in 2015. The BCA would progressively replace the current free allowance allocations for energy-intensive trade exposed (EITE) industries (free allowances become less effective at preserving firms' international competitiveness with deeper decarbonisation). A pragmatic case can be made for limiting the BCA (at least initially) to EITE industries[19] and using domestic industry benchmarks rather

16 35 cents per kilometer for distances of 21 kilometres or more.

17 For the issue on competitiveness, see for example, Dechezleprêtre and Sato (2017), Venmans et al. (2020). For the issue on carbon leakages, see Ellis et al. (2019), Misch and Wingender (2021) and Verde (2020).

18 Sometimes this instrument is referred to as a carbon border adjustment mechanism.

19 EITE industries account for about 85% of the emissions from manufacturing in the EU27.

than country-specific benchmarks to measure embodied carbon – this would simplify administration, limit burdens on emerging market economies, and perhaps lower the risks of legal challenges under the WTO (Parry et al. 2021).

Nonetheless, a far more effective approach for scaling up global mitigation – because it prices all emissions rather than the small fraction of emissions embodied in traded products – would be an international carbon price floor (ICPF). Under this approach, countries would agree on prices consistent with global mitigation goals and act simultaneously on the needed policies – this helps to address concerns that deter stronger unilateral ambition and policy actions (Parry et al. 2021). Such a 'minilateral' approach focusing on a small group of large emitting countries would facilitate negotiation. Country participants may support robust floor prices as this leads to bigger emissions reductions for all participants and bigger benefits for all – this is the key incentive to join the agreement. The arrangement can be designed pragmatically with differentiated price floors and transparent transfer mechanisms to address the differentiated responsibilities of developing countries. And countries for whom carbon pricing is politically difficult might be accommodated so long as they achieve equivalent emissions reductions through other mitigation measures.

CONCLUSION

To meet the ambitious emissions targets with greater certainty and cost effectiveness, Germany could enhance its mitigation measures by (i) further strengthening carbon pricing, for example through automatically rising price floors for the domestic ETS after 2026; (ii) harmonising carbon prices across sectors to reduce cross-sector differences in marginal abatement costs; and (iii) introducing feebates (revenue neutral tax-subsidy schemes) to reinforce incentives at the sectoral level. Our chapter also analyses the distributional impact of higher carbon pricing and suggests that reducing social security contributions can mitigate the regressive direct impact of higher carbon pricing on lower-income households. Concerns with carbon leakage and firms' competitiveness are best addressed through an international carbon price floor.

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CHAPTER 14

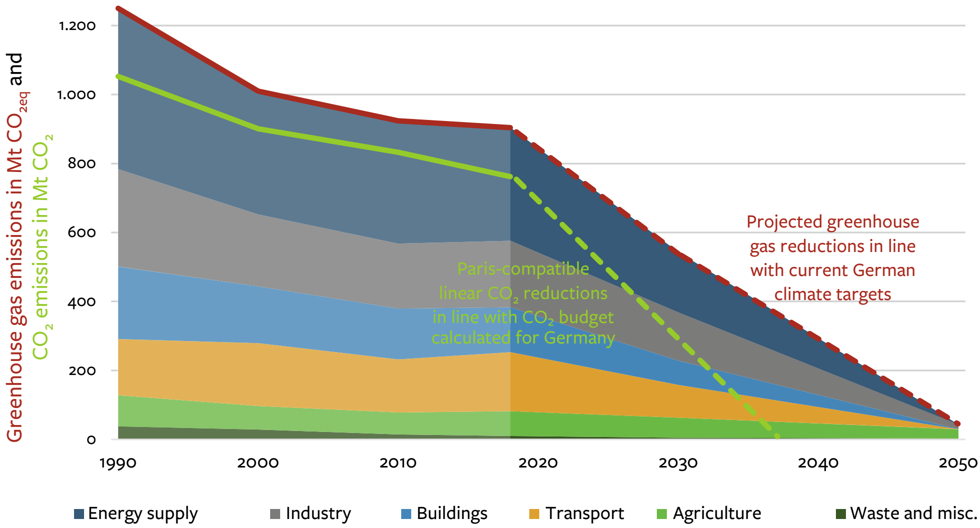
Climate protection in Germany: Good, but not yet good enough

Claudia Kemfert
DIW Berlin and Leuphana University

The year 2020 saw the beginning of fundamental global climate protection – especially in Germany. Greta Thunberg was the 'person of the year.' The Fridays for Future movement grew ever larger, ever more global and ever more successful. The movement is driving politics forward. A climate package is being developed. Europe has got the Green Deal on the way and wants to reduce greenhouse gas emissions even faster in all areas. At the same time, however, Saudi Aramco went public with a market capitalisation of around €2 trillion, and the first line of the Nord Stream 2 natural gas pipeline has been completed with the aim of bring even more fossil natural gas to Europe, and Germany, in the future. As a result of climate protection in the EU, however, hardly any fossil natural gas will be needed; renewable energies are already cheaper today (Kemfert at al. 2020)

It is becoming increasingly clear that climate change is occurring on a massive scale worldwide and that the climate policy pursued to date – despite international efforts – is inadequate. We are at the beginning of disruptive change towards more climate protection. Electric mobility is coming; renewable energies are becoming cheaper and cheaper. The European Investment Bank has even announced that it will no longer invest in fossil fuel projects. The recently completed and highly controversial pipeline is – similar to many coal-fired power plants in Germany and also worldwide – a 'stranded investment' (i.e. a bad investment at enormous cost). Fossil energies are experiencing increasing devaluation overall (Hirschhausen et al. 2018). The decade of fossil fuel fire-sales is beginning. All nations that generate high revenues from the sale of fossil fuels will have to change course. In order not to end up with a 'carbon bad bank' that has to scrap fossil fuel capital, this change of course should be initiated now. Europe is now seeking to establish the right framework conditions for sustainable financial markets.

FIGURE 1 EMISSION REDUCTIONS IN LINE WITH NATIONAL CLIMATE TARGETS AND PARIS-COMPATIBLE BUDGET FOR GERMANY



Source: SRU (2020).

As the World Economic Forum (2021) reported, the greatest global risk is climate change, followed by the extinction of species and the dangers of digitalisation. Blackrock, the world's largest asset manager, has called on companies to do more to combat climate change. "Every government, every company and every investor must address climate change", warned CEO Larry Fink in a letter to the heads of companies around the world in which the asset manager has a stake. Shortly before this letter, Blackrock had joined the Climate Action 100+ network, an alliance of international investors that is demanding from companies more transparency and comprehensible targets in the area of climate protection.

At the same time, an increasingly open fossil fuel energy war has been raging. Former US President Donald Trump introduced sanctions against the Nord Stream 2 natural gas pipeline, allegedly in order to protect Germany and Europe from dependence on Russia. In reality, however, his likely aim was to sell the United States' fossil fuels, above all natural gas obtained by fracking, to Europe at the highest possible price.

The best answer to fossil energy wars, whatever their nature, is to implement energy transitions locally, with more renewable energies, more energy saving and more electric mobility. Unfortunately, Germany's climate package, announced with great fanfare, turned out to be more of a small start than a big shot. It does not provide for what is necessary in terms of climate policy, only for what appears politically feasible.

It will not be possible to achieve the emissions reduction targets by 2030 with the measures adopted without readjustments. In the transport sector in particular, the climate targets will be missed by a wide margin. The phasing-out of coal is coming too late and is too halfhearted to achieve the climate targets. Worse still, the expansion of renewable energies is being slowed down so that, in addition to failing to meet the climate targets, there is also the threat of a shortfall in green electricity, which will endanger the security of supply. It is also regrettable that instead of environmentally harmful subsidies being reduced, they are being increased. Not removing the diesel privilege, or at least introducing a climate fee (for example, increasing the tax on kerosene), represents a failure. It is therefore inevitable that the emissions reduction targets will be missed and we will have to buy CO_2 certificates in Europe, at a cost of billions. Little climate protection for a lot of money – that will not exactly increase acceptance.

In December 2019, Germany's federal and state governments improved the climate package adopted in September following ongoing criticism. CO_2 prices were increased and the Renewable Energy Sources Act (*Erneuerbare-Energien-Gesetz*, or EEG) levy was reduced sharply. Despite these adjustments, however, the proposed CO_2 price path and subsequent emissions trading with a fixed price cap will still not be sufficient on their own to achieve the transport and construction sectors' climate targets for 2030, according to current calculations (Bach et al. 2019). In addition, social imbalances continue to arise due to additional burdens on low earners, even if this effect is somewhat mitigated by the reduction in electricity prices. There are various conceivable options to make the overall distributional effects of the reform progressive, including a mobility allowance (independent of the individual tax rate) instead of the commuter allowance and, above all, a uniform per capita climate premium that would, on average, more than offset the burden of the CO_2 price on low earners.

Concrete emissions reduction targets for individual sectors are indeed important, and the achievement of these targets should be reviewed annually and aligned with European targets. It is also important to press ahead more intensively with the expansion of renewable energies. Distance rules for wind energy are not very conducive to this, and the expansion cap for solar energy must also be abolished as soon as possible. In addition, no new oil-fired heating systems will be permitted from 2026 and more financial support will be given to energy-related renovation of buildings, as well as to rail transport. Charging infrastructure for electric cars and local public transport is to be expanded. However, it would have been even better to reduce the electricity tax so that more electricity from renewable energies is used in both the transport and the construction sectors.

Things are not going well with climate protection in Germany. While it is true that Germany will not miss its agreed emissions reduction targets for 2020 by as much as originally assumed, the measures adopted so far will hardly suffice to meet the climate targets by 2030. If we do not take action, we will be unable to meet either the targets agreed in Germany or the more ambitious ones that are actually necessary under the Paris Agreement climate resolutions. The CO_2 emissions budget will soon be exhausted. The longer we wait, the less time we will have and the less likely we are to achieve the Paris climate resolutions. Even the climate package for the transport and heating sectors is insufficient, and the improved CO_2 price increase is hardly sufficient. Since no rapid reductions in emissions are expected in the construction and transport sectors, the energy sector must do more, and as quickly as possible. This means that the phasing-out of coal must be completed as quickly as possible. Indeed, it must be completed by 2030 if we want to achieve the Paris climate resolutions and avoid the high costs of purchasing additional certificates in Europe.

However, the phasing-out of coal is a long time coming. A year ago, the German Coal Commission presented its recommendations for a concrete roadmap. It took a year to to develop a coal phase-out law from the recommendation report . One year was apparently spent discussing the matter primarily with coal companies, which unfortunately no longer had much common ground with the recommendations of the Coal Commission. At least two essential points were changed in the recommendations: the coal phase-out timetable provides for too much hesitation in power stations being shut down, for which – for the most part – lavish compensation is paid.

Aside from the delayed coal exit, the commissioning of a new power plant, Datteln 4, in the state of North Rhine-Westphalia is particularly regrettable. One can imagine the boss of the Volkswagen Group rubbing his eyes in amazement at a new coal-fired power plant being commissioned just as the Volkswagen Group is replacing its coal-fired power plants with natural gas plants (even better would be an energy supply consisting of 100% renewable energies – but that also applies to Tesla). The commissioning of Datteln 4 is a mistake for reasons of energy economy and above all for reasons of climate policy. The new plant alone will lead to additional emissions of 40 million tonnes of CO_2. Instead, an accelerated phase-out of coal could reduce emissions by more than 130 million tonnes overall. The delayed phase-out of coal will result in unnecessarily high emissions, and the energy industry as a whole will have to reduce its emissions by significantly more. This is particularly because the transport and construction sectors are unlikely to achieve such high emissions reductions in a short period of time. Moreover, renewable energies must expand much faster if we do not want to run into a green electricity supply gap. The phasing-out of coal must be accelerated if we are serious about climate protection. At the same time, the heating and transport sectors must do much more to reduce their emissions.

So, there is an enormous amount of work to be done. Emissions reduction targets must be brought into line with the Paris targets, and this means that emissions must fall faster than planned. As Germany's climate package is unlikely to allow this, coal-fired power stations must be taken off the grid as quickly as possible. The phasing-out of coal by 2030 is a first necessary step towards this . Renewable energies must expand quicker. If this succeeds, then climate protection in Germany will finally get back on track.

But perhaps the EU Green Deal now offers a remedy. Germany must further sharpen its climate targets and adapt to the more ambitious goals. At the same time, Europe wants to expand emissions trading to include the transport and construction sectors. This is why it is so important that Europe seeks to ensure its targets are met by introducing a climate law. Annual reviews and, if necessary, adjustments in the event of non-compliance are particularly important.

Climate protests will become even louder and more intense. This is only the beginning for courageous climate protection. With the EU Green Deal, Europe – and also Germany – can finally take on a pioneering role in international climate protection again. The year 2020 will perhaps go down in history as the 'tipping point' – the year when irreversible climate protection began and the fossil fuel sell-off heralded the aversion of the global climate crisis. In any case, it is high time!

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CHAPTER 15

Danish climate policy: Past achievements and future challenges

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TARGETS FOR DANISH CLIMATE POLICY

Denmark is one of several European countries that have managed to decouple their domestic greenhouse gas (GHG) emissions from the growth of GDP. Danish policymakers have long strived to place Denmark among the frontrunner countries in climate policy, and in 2020 the Danish Parliament passed a new Climate Act committing the country to reduce total domestic GHG emissions by 70% in 2030 relative to emissions in 1990 and to achieve zero net emissions by 2050, at the latest.

The Danish 70% reduction target for 2030 goes well beyond the 55% reduction target for the EU as a whole. Meeting the target is a major challenge, as several low-hanging fruit in Danish climate policy have already been harvested. This chapter will seek to identify some remaining low-hanging fruit and describe ways to overcome the barriers to emissions reduction in sectors where reductions have been hard to achieve.

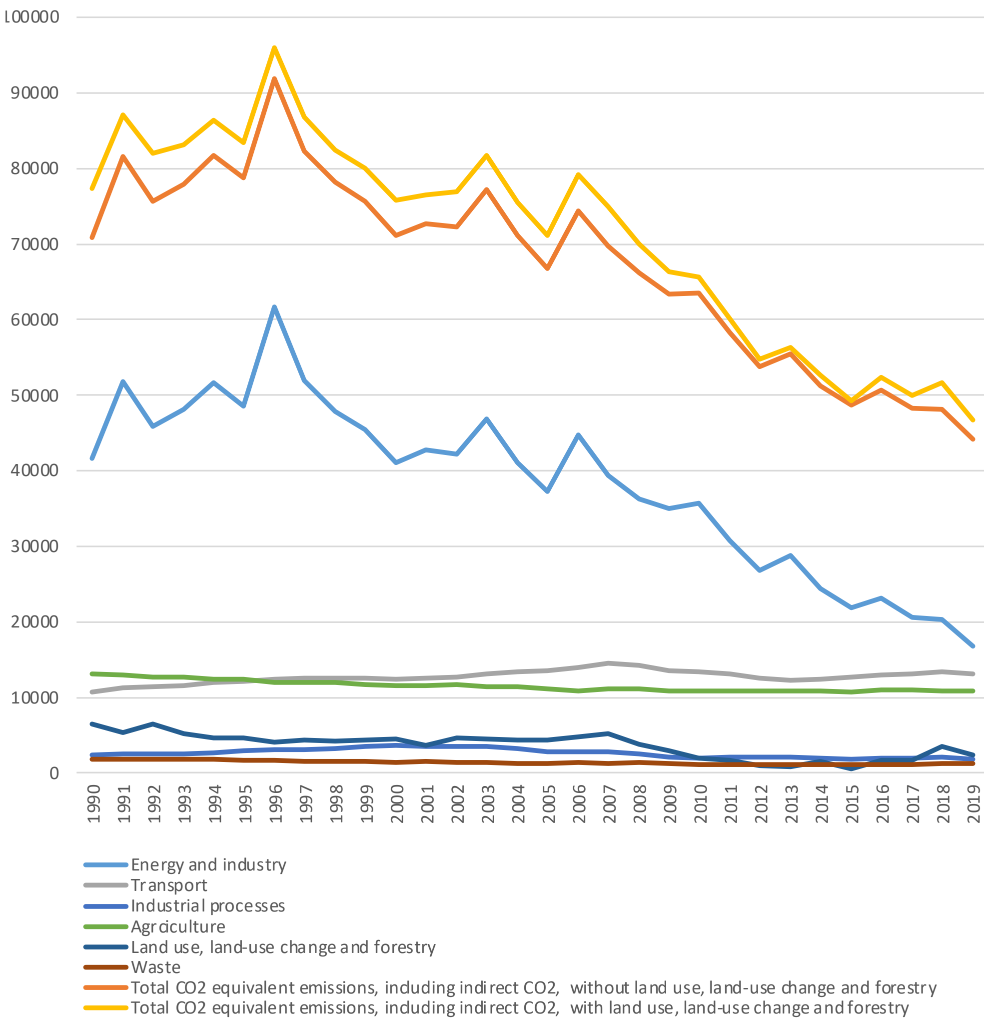
TRENDS IN DANISH GREENHOUSE GAS EMISSIONS

In 1990, the Danish government presented the world's first national action plan for the reduction of CO_2 emissions. The plan aimed at a 20% reduction of CO_2 emissions by 2005, to be achieved partly by the introduction of a carbon tax and higher energy taxes and partly by support for wind energy and measures to improve energy efficiency. After 1990, a succession of new energy plans and political agreements have gradually tightened the targets for Danish energy and climate policy and have led to a complex mixture of taxes, subsidies and direct regulation intended to promote renewable energy and energy savings.

1 Without implicating him in any remaining shortcomings, I thank Jørgen Henningsen for comments on an earlier draft of this chapter.

The impact of these policies is reflected in Figure 1, which illustrates the reduction of GHG emissions from Danish territory since 1990, as reported in Denmark's National Inventory Report 2021 to the United Nations. The figure reveals that the fall in emissions has been concentrated in the energy sector. Emissions from agriculture (mainly methane and nitrous oxide) fell somewhat from 1990 until the mid 2000s, primarily as a result of stricter regulation of the use of fertilizer aimed at reducing nitrate leaching to the water environment, but during the last 15 years agricultural emissions have remained roughly constant, and emissions from the transport sector have even increased since 1990 due to an increase in traffic.

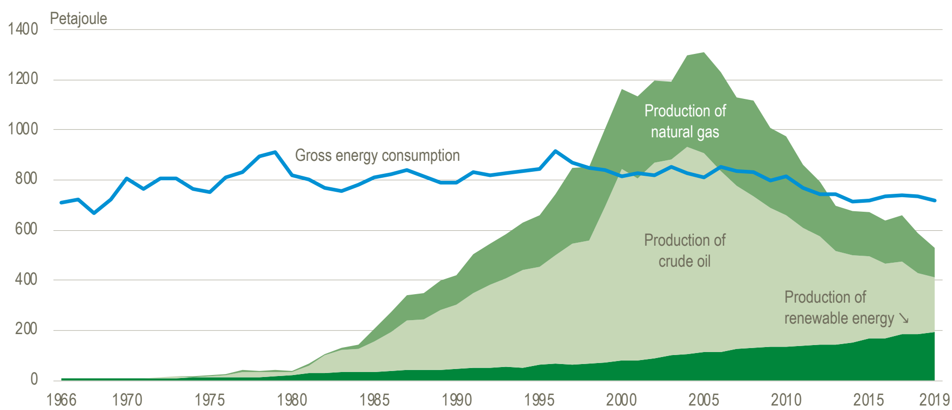
FIGURE 1 GREENHOUSE GAS EMISSIONS FROM DANISH TERRITORY (KILOTONNES CO_2 EQUIVALENTS)



Source: Danish Centre for Environment and Energy (2021).

The transformation of the Danish energy system is illustrated in Figure 2, which shows that gross energy consumption has stayed roughly constant since the mid-1960s. Since the Danish real GDP has tripled since that time, this amounts to a remarkable increase in energy efficiency. During the same period, Danish production of oil and natural gas in the North Sea rose from zero to exceeding domestic energy consumption by almost a third in the mid-2000s, followed by a recent decline as the most easily accessible reserves were gradually exhausted. At the same time, the production of renewable energy has increased.

FIGURE 2 ENERGY PRODUCTION AND ENERGY CONSUMPTION IN DENMARK



Source: Statistics Denmark.

In recent years, Denmark has been the third-largest Western European oil producer, but in 2020 the Danish Parliament decided to stop all new licenses for exploration for oil and gas on Danish territory. It was also decided that extraction of oil and gas under existing licenses must end no later than 2050. The motivation was that Denmark cannot claim to be a green frontrunner country while continuing to earn substantial incomes from the production of fossil fuel.

Over the last decade, the share of Danish electricity consumption covered by intermittent sources like wind and solar energy has doubled to more than 50% of total consumption (of which wind accounts for 46%) and is headed for a further increase. Despite the intermittency of supply from domestic sources, Denmark remains at the very top of international rankings of the security of electricity supply, due to a well-functioning network of international interconnectors that allows Danish consumers to draw on imported Norwegian and Swedish hydropower during periods with little wind.

The gains in energy efficiency and the maintenance of energy security are real achievements of the Danish energy system. It also took some political stamina to stop the exploration for oil and gas in the face of resistance from strong lobby groups. However, there are other less flattering aspects of Denmark's green transition. First, studies of the global carbon footprint (the total global emissions) caused by expenditures undertaken by Danish residents indicate that the consumption-based emissions per capita are considerably higher than the emissions per capita from Danish territory, implying that Danish consumption and investment is more carbon-intensive than Danish production. A recent study by Hjarsbech (2020) found that while the CO2e emissions from Danish territory fell by 30% from 1990 to 2015, the Danish carbon footprint only fell by 7.4%.

Second, although much attention has focused on the expansion of the Danish wind industry, the Danish consumption of renewable energy from wood-based biomass is actually twice as high as the consumption of wind energy. The replacement of coal by wood-based biomass in the form of wood chips and wood pellets in the production of heat and electricity was made profitable by the exemption of biomass from the high Danish energy tax. As a result, Denmark's net import of wood-based biomass per capita is the largest in the EU, and the Danish consumption of biomass per capita is far above the level estimated to be environmentally sustainable on a world basis. Moreover, there is a heated debate on the extent to which wood-based biomass should be regarded as a carbon-neutral source of energy.

DANISH CLIMATE POLICY: CURRENT STATUS

By 2019, Denmark had reduced its total domestic GHG emissions (including emissions from land use, land-use change and forestry, or LULUCF) by 40% relative to emissions in 1990. In the spring of 2021, the Danish Energy Agency (DEA) published its latest forecast of the evolution of domestic GHG emissions towards 2030, given the climate policies already implemented or agreed upon by a majority in the Danish parliament, but assuming no further policy initiatives. Existing policies include recent political agreements on various measures to reduce emissions from industry, waste treatment and transport through a mixture of changes in taxes, subsidies and direct regulation. The DEA estimates that, with current policies, total domestic emissions will be 55% lower in 2030 than they were in 1990. Hence there is a need for new policy measures that will reduce emissions in 2030 by a further 15 percentage points of 1990 emissions to meet the Danish 2030 target of a 70% emissions cut.

By 2030, the DEA expects that emissions from the production of electricity, district heating and individual residential heating will only account for 2% of total Danish emissions, due to a phase-out of the use of coal and a further expansion of power production from wind and solar sources and increased use of electricity-driven heat pumps as well as increased production of biogas. Emissions from manufacturing and construction are estimated to account for 10% of total emissions by 2030, while the production of oil, gas and renewable fuels and the treatment of waste are expected to be responsible for 6% and 5% of total emissions, respectively. Emissions from agriculture and land use (LULUCF) are estimated to represent a striking 46% of total 2030 emissions, and the transport sector is expected to account for 33% of total domestic emissions. These numbers indicate that the fulfilment of the Danish 70% target for emissions reduction by 2030 will depend crucially on the country's ability to reduce emissions from the two sectors where GHG abatement has so far proven to be very difficult.

IDENTIFYING LOW-HANGING FRUIT IN DANISH CLIMATE POLICY

In the following sections, I will briefly review the options for cost-effective cuts in greenhouse gas emissions from agriculture, land use, transport, and other sectors of the Danish economy. Examples of low-hanging fruit in Danish climate policy are summarised in Table 1 below. The estimates in the table are primarily taken from the report by the Council on Climate Change (2020), an independent expert body established by law to monitor progress towards fulfilment of Denmark's targets for climate policy and to advise the Danish government and Parliament on ways to meet the targets. In a few cases, I have adjusted the estimates of the Council to account for new information contained in the report by the Energy Agency (2021), reflecting changes in the agency's forecast of emissions due to new policy initiatives taken after the Council's 2020 report.

The "Transition elements" in the second column of Table 1 are changes in technologies or patterns of production and consumption that have the potential to reduce greenhouse gas emissions from Danish territory. I consider the transition elements in the table to be 'low-hanging fruit' because they all meet two criteria: 1) they are based on known (tried and tested) technologies; and 2) they involve a low or medium social cost per tonne of CO_2e emissions cut. Following the Council on Climate Change, I consider the social cost to be 'low' if it is smaller than 400 DKK (roughly €54) per tonne of CO_2e emissions reduction, and I define the social cost to be 'medium' if it is less than 1,000 DKK (about €134) per tonne of CO_2e emissions cut. To put these numbers in context, the Council on Climate Change has estimated that the marginal social cost of meeting the Danish 70% reduction target for 2030 may be as high as 1,500 DKK (roughly €200) per tonne of CO_2e. The estimated social costs include non-climate related external costs and benefits associated with the various transition elements.

The "technical reduction potentials" reported in the third column of Table 1 are estimates of the total annual emissions cuts obtainable in 2030 without exceeding the upper limit for the social cost per tonne of CO_2e reduction (low or medium) stated in the fourth column of the table. The numbers in brackets indicate the reduction potential measured in percent of the total further reduction of 11.8 mt CO_2e required to meet the 2030 target. Typically, it may be possible to implement a transition element in different ways using different policy instruments (e.g. taxes, subsidies, or direct regulation), and the choice of policy instrument may affect the social cost per tonne of CO_2e reduction. The implicit assumption underlying the cost estimates in Table 1 is that policymakers choose policy instruments that are reasonably cost effective. I will return to this issue later.

It should be stressed that the estimates in Table 1 are subject to considerable uncertainty and to ongoing debates and revisions as new information becomes available.

TABLE 1 EXAMPLES OF LOW-HANGING FRUIT IN DANISH CLIMATE POLICY

Sector	Transition element	Technical reduction potential in 2030 (million tonnes CO_2e)[a]	Social cost[b]
Agriculture	Conversion of organogenic soils	1.4 (12%)	Low
	Targeted reduction of fertilizer use	0.5 (4%)	Low
	Better handling of slurry	0.4 (3%)	Low
	Altered feed to dairy cattle	0.2 (2%)	Medium
	Reallocation of production areas	0.4 (3%)	Medium
Transport	Electric vehicles for personal transport	(8%) (1 million EVs in 2030)	Medium
	Electric delivery vans	0.5 (4%) (100,000 EDVs in 2030)	Low
	Carbon-neutral trucks	0.2 (2%)	Low
	Carbon-neutral buses	0.1 (1%)	Medium
Other sectors	Energy savings in industry and buildings	0.6 (5%)	Low
	Biomass in industrial processes	0.3 (3%)	Low
	From coal to gas in industrial processes	0.3 (3%)	Medium
	Reduction of leakage from biogas plants	0.2 (2%)	Low

Notes: a) The number in brackets indicates the reduction potential in percent of the total further emissions reduction needed to attain the Danish 2030 reduction target (11.8 mt CO2e). b) Low social cost < 400 DKK (€54) per tonne of CO2e reduction. Medium social cost < 1000 DKK (€134) per tonne of CO2e reduction.

Sources: Council on Climate Change (2020), Energy Agency (2021) and own calculations.

REDUCING EMISSIONS FROM AGRICULTURE AND LAND USE: LOW-HANGING FRUIT

While only 13% of Danish land is covered by forest, agricultural crops cover almost two-thirds of the land area. This is more than twice the EU average cropland cover. Moreover, Danish agricultural production is very intensive in terms of animal husbandry per hectare. For these reasons, emissions of methane and nitrous oxide account for a relatively large share of total Danish emissions.

The upper part of Table 1 provides some examples of relatively cheap options for reducing emissions from Danish agriculture. The most obvious reduction measure is to stop cultivating carbon-rich organogenic soils. When these areas are no longer drained and ploughed, the release of CO_2 from the soils to the atmosphere slows down. As environmental side benefits, the leaching of nitrate to the water environment and the evaporation of ammonia into the air are reduced.[2]

However, there is considerable scientific uncertainty about the true potential for conversion of organogenic soils and in many cases it will require coordination among several farmers, as the conversion of these soils into wetlands may have spillover effects across landowners.

According to the Ministries for Food and the Environment, a targeted reduction of fertilizer use on the agricultural fields where the nearby water environment is particularly vulnerable to nitrate leaching will have a *negative* social cost per tonne of CO2e reduction, due to the side benefits in the form of an improved aquatic environment. Another low-hanging fruit is better handling of slurry, which involves more frequent removal of slurry from stables and acidification of slurry – measures that reduce the emissions of methane and nitrous oxide and the evaporation of ammonia.

Transition elements with medium social costs include adding more fat to the feed of dairy cattle to reduce their emissions of methane, and reallocation of agricultural land to areas with grass, forest or energy crops.

According to the (uncertain) estimates in Table 1, these transition elements in agriculture and land use could provide cuts in GHG emissions amounting to almost a fourth of the remaining reductions needed to meet the Danish 2030 target, and most of these cuts could be achieved at a low social cost.

LOW-HANGING FRUIT IN TRANSPORT AND OTHER SECTORS

The middle part of Table 1 indicates that there is less scope for low-cost cuts in CO2 emissions from the Danish transport sector. The main reduction potential seems to stem from a transition to more electric vehicles (powered by green renewable energy) for personal transport.

There is an ongoing debate between engineers and economists on the relative social costs of electric vehicles (EVs) and conventional vehicles (CVs) driven by gasoline or diesel. EVs have higher capital expenses due to a higher purchase price, but lower operating expenses than comparable CVs. Measured over the expected lifetime of the vehicle, EVs are currently not much more expensive than CVs, so switching to EVs has a low social cost according to the engineers.

2 On the other hand, when low-lying organogenic soils are turned into wetlands, phosphorous may be released to the water environment, involving an external environmental cost.

Economists take a different approach based on observed consumer behaviour. In Denmark the total *private* cost of an EV over the lifetime of the vehicle is currently *lower* than the total private cost of a CV of comparable size and quality, due to a strongly reduced registration duty on EVs. Despite this, the sale of EVs only makes up a minor fraction (about 7% in the spring of 2021) of total new car sales. Economists conclude from this that there must be features of EVs that make them less attractive than CVs. One barrier to the adoption of EVs is the fear that they have insufficient range to reach their destination, due to lack of an extensive charging infrastructure. Another disadvantage of EVs is the relatively long time it takes to recharge their batteries compared to the time required to fill the tank of a CV. If EVs have such disadvantages, there may be significant welfare costs of switching from CVs to EVs even if the differences in total costs (before taxes and duties) of the two types of vehicles may be small.

However, the charging infrastructure is gradually being extended, the range of new EVs (before recharging is needed) is increasing and the recharging time is declining, so the welfare cost of switching to EVs may soon become negligible. Indeed, the share of EVs in new car sales in Denmark almost doubled between the spring of 2020 and the spring of 2021, indicating that consumer preferences are shifting in favour of EVs. Hence Table 1 may underestimate the reduction potential from EVs for personal transport and overestimate their social cost. According to the table, the social cost of switching to electric delivery vans is already low, but overall, the table suggests that the remaining low-hanging fruit in the transport sector can only deliver CO_2 reductions amounting to about 15% of the further reductions needed to fulfil the 2030 target.

The bottom part of Table 1 offers examples of low-cost or medium-cost options for reducing GHG emissions from other sectors of the economy. Together, these transition elements could deliver about 12% of the further emissions cuts needed to meet the 2030 target. But in total, all the low-hanging fruit in Table 1 can only provide about half of the cuts needed to fulfil the target.

BEYOND THE LOW-HANGING FRUIT: THE DEVELOPMENT TRACK

Against this background, the Council on Climate Change (2020) has outlined a "development track" for Danish climate policy, emphasising the need to develop further transition elements based on technologies that are still immature and potentially quite costly in their current form. Table 2 gives examples of the most important transition elements analysed by the Council and its evaluation of the probability that they can be implemented in 2030 at a social cost per tonne of CO_2e reduction which is not "unreasonably" high.[3]

3 The Council considers a cost per tonne above 2,000 DKK (€268) to be "very high", so presumably the cost should exceed this level to be considered "unreasonably" high.

TABLE 2 THE DEVELOPMENT TRACK: EXAMPLES OF HIGHER-HANGING FRUIT IN DANISH CLIMATE POLICY

Transition element	Technical reduction potential in 2030 (million tonnes CO_2e)[a]	Probability of feasibility
Carbon capture and storage (CCS)	4.5 (38%)	High
More electric vehicles in personal transport (1.5 million in 2030)	0.8 (7%)	Low
New food habits and new technologies in agriculture	2.0 (17%)	Medium
Electrification of drilling platforms	0.5 (4%)	Medium
Pyrolysis for bio coke and fuel production	4.0 (34%)	Low
Power-to-X in refineries, gas network and ferries and aircraft	0.9 (8%)	High to low

Note: a) The number in brackets indicates the reduction potential in percent of the total further emissions reduction needed to attain the Danish 2030 reduction target (11.8 mt CO2e).

Source: Council on Climate Change (2020).

The most promising transition element seems to be technologies for carbon capture and storage (CCS) which can be applied to biogas plants, some large-scale industrial plants and incineration plants, and biomass-fired combined heat and power plants to achieve negative net emissions. The Council has estimated that, with high probability, CCS can deliver significant emissions reductions at a total cost (including storage) of 1,000–1,250 DKK (€134–168) per tonne of CO_2.

Another technology with a large reduction potential is pyrolysis, where biomass waste products are heated in the absence of oxygen to decompose the material into biochar and gas. The gas can be liquified to produce synthetic fuels that can replace fossil fuel in, for example, airplanes and the biochar can be used to store carbon in agricultural land for centuries, potentially improving the quality of the soil and helping to reduce net emissions from land use. According to the Climate Council, there is only a small probability that the full reduction potential offered by pyrolysis can be realised by 2030, but other observers are more optimistic about this technology.

Power-to-X technologies use green electricity in electrolysis to produce hydrogen which can be used directly as a fuel or be combined with other chemicals to produce synthetic fuels. Such fuels may replace fossil fuels in those types of heavy transport that are hard to electrify. However, while power-to-X technologies may be key to reducing emissions from international transport, they are still expensive and will only help to fulfil the Danish 2030 target to the extent that they contribute to lower emissions from domestic transport.

Switching to new food habits and new technologies in agriculture, including more plant-based food products and diets, would allow further cuts in agricultural emissions, as indicated in Table 2. Although it is hard to evaluate the feasibility of implementing all the transition elements in the table by 2030 at a reasonable cost, their total technical reduction potential is considerable, suggesting that meeting the 2030 target of 70% emissions reduction should be possible.

EMISSIONS TAXES AND CARBON LEAKAGE

Fulfilling the 2030 target will undoubtedly require multiple policy instruments, including intelligent use of subsidies, direct regulation and public investment. Developing the new immature technologies in the "development track" will also require experimentation with advanced forms of public tenders that allow a 'competitive dialogue' between the procurers of new technologies and potential suppliers about the exact ways in which the problem at hand can be solved.

Moreover, practically all experts in the Danish debate agree that a substantial tax on GHG emissions, providing a strong incentive for GHG abatement across all sectors in the economy, is a very important element in a cost-effective climate policy. This raises several thorny issues. One of these is the difficulty of measuring non-CO_2 emissions from individual farm units, which is necessary if farmers are to be included in a GHG tax scheme. However, a report from the Council on Climate Change (2016) has illustrated how the authorities could estimate the emissions from each farm by coupling the existing statistical information on the operation of individual farms (number and type of animals, use of land and fertilizers, etc.) with the emission coefficients used to calculate emissions from agriculture and land use in Denmark's annual National Inventory Reports. Experts are currently working to refine such a methodology for calculating emissions from individual farm units as an informational tool for farmers who would like to reduce their emissions, and such a 'climate account' could be used as a basis for an emissions tax on agriculture.

Another issue is how to counteract the regressive distributional effects of a high emissions tax. The Danish think tank Kraka (2020) has shown that a carbon tax will tend to weigh more heavily in the household budget the lower the level of household income, but Denmark already has high taxes on household energy use which are also regressive and which could be lowered to offset the negative distributional effect of the carbon tax. Indeed, Kraka (2020) has demonstrated that the high Danish energy tax on household electricity use is more regressive than a carbon tax, and since electricity is increasingly produced by wind and solar energy, a switch from the electricity tax to a carbon tax would yield a 'double dividend' by reducing CO_2 emissions while at the same time generating a more equal distribution of income. However, a carbon tax may also weigh heavily on commuters living in remote areas with little or no access to public transport. To compensate for this, the government could invest in a charging infrastructure that makes it more attractive for people in remote areas to switch from conventional to electric vehicles.

Avoiding extensive GHG leakage is another major concern for a frontrunner country engaging in ambitious unilateral climate policy. In theory, leakage may be prevented by imposing a tax on the estimated carbon content of imported goods and offering a rebate for (part of) the domestic carbon tax on the production of exported goods, but an EU member state like Denmark cannot unilaterally introduce such a system of border carbon adjustments. However, a similar effect may be achieved by combining an emissions tax with an output subsidy to GHG-intensive products and a corresponding consumption tax on such products, as shown by Kruse-Andersen and Sørensen (2021). Such a system would counteract leakage at the *intensive margin* where emissions leak abroad as domestic firms lose market shares to foreign competitors due to the emissions tax. Moreover, leakage at the *extensive margin* where firms may relocate their entire business to a foreign country in reaction to the tax may be countered via a lump sum tax credit to domestic firms based on their historical emissions and activity, as Kruse-Andersen and Sørensen (2021) demonstrate. A Danish government expert committee is currently investigating these and other ways to design a GHG emissions tax scheme that can minimise leakage effects without violating EU and international trade and competition rules.

CONCLUDING REMARKS

By aiming at a 70% reduction of domestic greenhouse gas emissions by 2030 relative to 1990, policymakers have set a highly ambitious target for Danish climate policy. Analyses by the Council on Climate Change (2020), Kraka (2020) and the Environmental Economic Council (2021) suggest that the target can nevertheless be met at a moderate social cost of about 0.5–1% of GDP. This chapter has outlined ways to fulfil the target while minimising GHG leakage and avoiding negative effects on the distribution of income.

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CHAPTER 16

Norway: A large importer of electric cars and a large exporter of oil

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INTRODUCTION

Should a country only care about its own emissions? Or should it also consider the impact on global emissions when designing its climate policy? If all countries had binding commitments on their own emissions, the effect on global emissions of one country's actions would be identical to the effect on the country's own emissions. However, in the real world, and despite the Paris Agreement, emissions commitments are for many counties much weaker and vaguer. Climate policies in one country may therefore have impacts on emissions in other countries. In particular, some domestic emissions-reducing policies in a country may increase emissions so much in other countries that the global effect of the policies is negligible (or worse, they may increase global emissions). There may also be examples of the opposite case – a policy in a country may have little or no effect on the country's own emissions, but nevertheless contribute significantly to global emissions reductions.

In this chapter, I will illustrate the above points using two important aspects of Norway's climate and energy policies, namely, Norway's policy towards electric cars and its policy for its petroleum sector.

ELECTRIC CARS

About half of all new private cars in Norway are electric, and a significant share of the remaining cars are plugin hybrids. Norway's policy goal is that by 2025 all new cars will be one of these two types.

Clearly, the large number of electric cars has had – and will have in the future – a significant effect on Norway's CO_2 emissions. The exact amount is of course difficult to know, as it not easy to calculate what the electric cars are replacing. Probably they mostly replace traditional gasoline and diesel cars, but to some extent the electric cars could be a household's second car, and could result in more driving overall instead of public transportation.

How has Norway achieved this massive transition to electric cars? A high general carbon tax (about €50 per tonne of CO_2 for most sectors outside the EU Emissions Trading Scheme), as well as other fuel taxes, has obviously helped. Probably more important is the design of taxes on new cars. Since 1955, Norway has had quite a high tax on the purchase of a new car. For regular cars, the total tax (including VAT) is about 50%, while the standard VAT for other goods and services is 25%. For electric cars there is no such tax – not even the standard VAT. There are also other benefits for electric cars, such as free parking on public areas, reduced charges on toll roads, and permission to use bus lanes where they exist.

The regulation described above is not without costs. The costs per tonne of CO_2 saved is obviously difficult to calculate, partly because (as mentioned above) it is difficult to know by exactly how much CO_2 emissions have declined due to the transition to electric cars. The Norwegian national budget for 2020 (Ministry of Finance 2019) has surveyed some cost calculations, and all of these suggest costs per tonne of CO_2 avoided to be more than €500. This is a very high cost, both compared with the EU ETS quota price and with the general CO_2 tax used in the non-ETS sectors (about €50). Even restricting oneself to the non-ETS sectors, this suggests that efficiency gains can be achieved by increasing the general CO_2 tax and reducing some of the benefits of electric cars.

While the direct emissions from electric cars are zero, the electricity produced for the cars is not without emissions. Norway's electricity production (with the exception of the offshore petroleum sector) is almost 100% renewable (with nearly all of this being hydro). Hence, emissions from electricity production are not relevant as long as the focus is only on emissions within Norway's boundaries. However, Norway is closely linked to the European electricity market, so any change in the use of electricity in Norway will be almost completely matched by a similar change in European electricity production. On the margin, a considerable part of this is from coal fired plants – at least now and in the near future. (For this reason, I have some colleagues who refer to electric cars as 'coal cars'). By this reasoning, although electric cars reduce CO_2 emissions in Norway, they increase emissions in the rest of Europe.

Since the combined energy efficiency of modern coal-fired power plants and electric motors is typically higher than that of combustion engines, it is tempting to conclude that the sum of European emissions declines. This might be true, but what about global emissions? To answer this, we must consider the market for oil and coal in more detail. Imagine for a moment that the supply of oil is completely inelastic. If this were the case, the lower oil demand due to the transition to electric cars would have no impact on global oil production and use – the only effect would be to lower oil prices. Hence, CO_2 emissions from oil would be unaffected. If at the same time coal supply was price sensitive, the increased demand for coal due to an increase electricity production would lead to more CO_2 emissions from coal. The net effect of this would hence be that the transition to electric cars increased global emissions of CO_2. In reality, the supply of oil is of course not completely inelastic. However, the conclusion could nevertheless be valid even if oil production is price responsive, provided the supply elasticity for oil is sufficiently small relative to the supply elasticity for coal.

The reasoning above ignored the presence of the EU ETS. There are a given amount of quotas supplied in this system every year, declining over time. Over time, total emissions from the sectors covered by the EU ETS are therefore given. Coal power plants are included in this quota system, so that any increase in emissions from coal (due to increased electricity demand from electrical cars) will be matched by a similar reduction elsewhere within the quota system (now or in the future). Oil for transportation, on the other hand, is not part of the ETS, so reduced demand for oil will in fact give lower European emissions. Therefore, the total effect on CO_2 emissions from Europe is that they will decline as a consequence of the increased sale of electric cars.

A final and important complication has to with the existence of the EU's mandatory emissions reduction targets for new cars. As with all EU regulations, the detailed rules are quite complex. The short version is that this regulation implies that the average CO_2 per kilometre for all new cars sold in EU cannot exceed a limit set by the regulation. For 2021 this limit is 95g CO_2 per kilometre for passenger cars. As long as this limit is binding, any additional policy promoting electric cars will have no effect on the emissions from the total fleet of new cars; the policy will simply make it easier for the car manufacturers to satisfy the regulated average emissions per kilometre. Subsidising new electric cars will in fact be a subsidy for the whole fleet of new cars, since the composition of new cars will be determined by the regulation. This is related to a general property of renewable portfolio standards pointed out by, among others, Greaker et al. (2014): a subsidy for renewable energy when a renewal portfolio standard is binding is a subsidy for *all* energy, hence also increasing the use of dirty energy. Subsiding the purchase of electric cars may hence increase the number of new cars sold, and therefore also emissions. Although this effect is likely to be quite weak, it illustrates the fact that the effect of subsidising electric cars on European and global emissions is by no means obvious.

Summing up, *if* the EU emission standards were completely exogenous and binding, subsidising new electric cars would have no effect on emissions from the total fleet of cars (unless the total number of cars increases, in which case emissions also increase). The only possible effect on total EU emissions would then potentially be from the use of coal for generating electricity. Electricity generation is, however, covered by the ETS, so it is not obvious that increased electricity production would lead to more emissions. In reality, the future EU emission standards might depend on the present and future number of electric cars, thus making it more difficult to conclude how a subsidy to electric cars affects global emissions.

NORWAY'S OIL AND GAS PRODUCTION

Norway is a large producer and exporter of oil and gas. There are large CO_2 emissions related to this petroleum production – about 31% of Norway's total CO_2 emissions. These emissions are covered by the EU ETS. In addition, there is a domestic carbon tax on these emissions, so that the total carbon price per tonne of CO_2 emissions is more than €50.

Although the emissions from the production of petroleum are large relative to Norway's total emissions, they are small (about 3%) compared to the emissions caused by the use of the exported petroleum. This use is by other countries, and one could therefore argue that these emissions are not Norway's responsibility. Nevertheless, if Norway reduces its oil production, global CO_2 emissions will decline. Reduced oil exports will to some extent be replaced by increased oil production in other countries, but in spite of this there will be a net reduction in global production and use of oil, and hence in CO_2 emissions. Fæhn et al. (2017) have suggested that the 'supply-side carbon leakage' for Norway's oil exports might amount to about two-thirds, so that each tonne of reduced Norwegian oil production implies a third of a tonne reduction in global oil production, with associated emissions.

The reasoning above has made some argue that reduced oil production should be part of Norway's climate policy. In particular, it has been argued that that Norway, as a rich country, has a moral obligation to reduce its petroleum production and thereby reduce global CO_2 emissions. The majority of Norwegian politicians disagree, typically using at least one of three arguments: (1) carbon leakage is closer to one than two-thirds, so that reduced Norwegian oil production will be almost completely offset by increased production in other countries; (2) emissions in other countries are not Norway's responsibility according to the Paris Agreement; or (3) reducing Norwegian oil production will be very costly for Norway. The first argument is an empirical issue, but the theoretical arguments for the ratio of carbon leakage being close to one are weak. In Hoel (2014), I argued in fact that the long-run ratio of carbon leakage may be close to zero. The second argument has already been briefly mentioned in the introduction. In the rest of this discussion, I therefore focus on the third argument.

A rapid and complete shutdown of the Norwegian petroleum sector would be enormously costly for Norway. However, this does not mean that any reduction in the amount of oil produced would have large costs. Production from existing petroleum fields faces gradually increasing unit costs as production declines over time, and production stops when the unit costs exceed the price of petroleum. Clearly, towards the end of a field's lifetime, the profits are small and declining. Closing a field somewhat earlier than when profits become zero therefore only has a small cost.

The profitability of all new investment projects is highly uncertain. Some projects have a high expected surplus (net present value), while some potential investment projects are likely to be only marginally profitable. Abstaining from investing in these marginal projects thus has small expected costs for Norway, while contributing to reduced global CO_2 emissions.

The discussion above did not mention the tax system for the Norwegian petroleum sector. The tax rate for this industry is 78%. If all costs and all revenue faced this tax rate, the tax system would not affect investment and operation decisions. However, the tax system is designed such that the tax credit for investments is higher than the 78% that the revenue is taxed by. After a recent (and perhaps temporary) change in the tax system following the decline in oil prices in early 2020, 91.4% of investment expenditures are credited in the form of reduced taxes. Hence, the petroleum companies keep 22% of their income (net of operating costs), but only pay 8.6% of the investment expenditures. It is straightforward to show that this tax system is equivalent to a pre-tax investment subsidy of 61%, combined with a neutral tax at a rate of 78% on all income and expenditure. This creates an enormous distortion in investment incentives. Consider a project with investment costs of 100 'somethings' (the units don't matter). Obviously, the expected present value of the net income must exceed 100 for such a project to be profitable for Norway. But with the tax system, the project will be profitable for any present value of net income exceeding 39. Clearly, any project that is undertaken in spite of the present value of income being below 100 is economically bad for Norway. So even ignoring the foreign CO_2 emissions from such projects, they ought not to be undertaken.

LOW-HANGING FRUIT IN NORWEGIAN CLIMATE POLICIES?

For Norway's domestic emissions, unfortunately, there seem to be no low-hanging fruit (i.e. there are no unexploited policies that would reduce emissions at low or zero cost). About half of Norway's emissions are in sectors covered by the EU ETS, so these emissions are determined by this quota system. Almost all of Norway's remaining CO_2 emissions face a carbon tax of about €50 per tonne of CO_2, and the current government has announced that this tax will increase to almost €200 by 2030. Some sectors have been exempted from this tax previously, but these exemptions are being phased out. Norway's generous (and costly) policy of promoting electric cars has also contributed to lowering the country's domestic emissions. However, for the reasons given in this chapter, it is not obvious that this policy will contribute much to reducing global emissions.

If one is concerned not only with Norway's domestic emissions but also with the effects of Norwegian policies on global emissions, there is one obvious low-hanging fruit. Independent of any climate concerns, there are good economic reasons for changing the petroleum tax system so that the private profitability of petroleum investments is weakened. Such a change in the tax system will not help Norway reach its goals for domestic emission reductions. However, to the extent that the change in the tax system eliminates some marginally profitable investments in the petroleum sector, the change in the tax system will reduce global emissions. The government has recently (August 2021) proposed a change in the petroleum tax system that will eliminate the difference between social and private profitability of petroleum investments. It remains to be seen whether this proposal will pass the parliament.

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CHAPTER 17

Sweden: Finance negative emissions and remove the transport sector target

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LOW-HANGING ABATEMENT FRUIT AND THE TRANSITION TO CLIMATE NEUTRALITY

Sweden, the EU and hopefully the world will embark on a transition to climate neutrality. Given the very large uncertainty both about the climate consequences of emitting CO_2 and about the consequences for human welfare of climate change, it is natural to think that the prudent policy is to immediately phase out all use of fossil fuel. However, the cost of doing this would be immense – not only in money terms but also, and much more so, in terms of human lives and welfare. An orderly transition to global climate neutrality based on pricing emission over three decades, on the other hand, need not be very costly. In fact, a thorough analysis by the IMF recently showed that the transition can be done with negligible consequences for economic growth and manageable distributional effects (IMF 2020). A policy that induces such a transition is robust to the policy errors that are inevitable given the large uncertainty about the consequences of emitting greenhouse gases. Also it if turns out that climate sensitivity is much lower than the scientific best guess, the transition has quite limited costs. Thus, it is a form of good insurance.

A key problem with the slow phase-out approach, relative to immediate banning, is that the question of what activities should go first becomes salient. Should some activities, individuals, firms, sectors, or countries go faster while some others are allowed to delay the transition? Or is the reasonable approach instead the same yearly haircut everywhere in society? But if so, from which base level?

It is sometimes argued that since all emissions will eventually need to be phased out, there is little value in looking for low-hanging abatement fruit. Instead, fairness speaks in favour of an equal phase-out speed across the economy. However, this argument is based on the premise that the relationship between the speed of adjustment and cost is the same everywhere in the economy. This is a false premise. Some parts of the economy are more flexible than others, depending on factors like the need for new technology developments and the size and depreciation rates of existing fossil-dependent capital stocks. Low-hanging abatement fruit is thus not only cheap emissions reductions but also reductions that do not require the development of new technologies and that do not require the scrapping of capital stocks with long potential life spans. A transition that allows different phase-out speeds across the (global) economy is not very costly, but one where this is not allowed may very well be.

SWEDISH EMISSION ABATEMENTS AND CLIMATE POLICIES

In Sweden, the transition to climate neutrality began 50 years ago. CO2 emissions had until then increased in parallel with GDP and global emissions. The first decades, CO_2 emissions fell at a high rate due to a large expansion of nuclear power and district heating. After that, gross emissions have fallen at a somewhat lower rate (see Figure 1).

Swedish territorial gross emissions of greenhouse gases (not netting out uptake by changes in land use in land and forests) fell by 29% between 1990 and 2019. Net emissions – i.e. deducting net uptake from forestry and changed land use – have fallen faster, by 56% between 1990 and 2019.

FIGURE 1 INDEX OF SWEDISH AND GLOBAL EMISSIONS OF FOSSIL CO_2

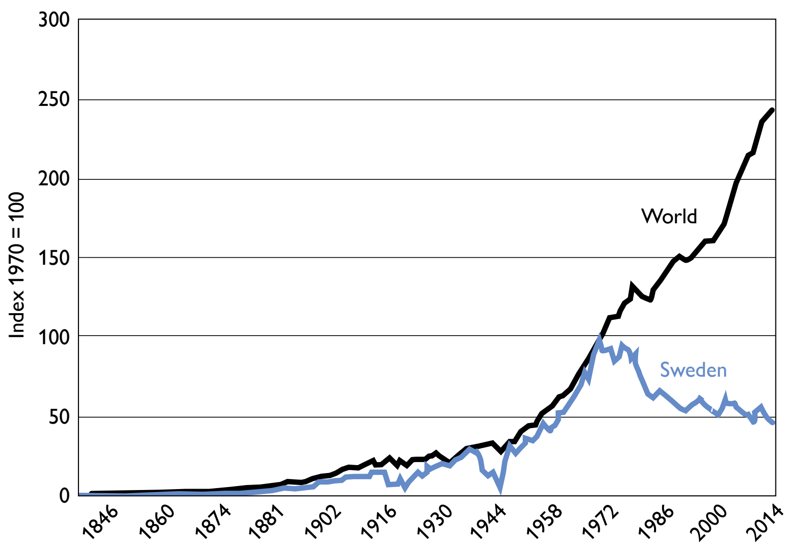

Figure from Hassler et al. (2020). Data source: Carbon Dioxide Information Analysis Center.

Across sectors, the reduction is far from uniform, as seen in Table 1. Emissions from industry and domestic transportation have fallen a bit less, while emissions from foreign transportation, not included in gross territorial emissions, have increased quite dramatically. At the other end of the spectrum we find local heating and waste disposal, where emissions have fallen quite dramatically, by 91% and 71%, respectively. The uptake of CO_2 in forests and land has been relatively constant in absolute terms over the three decades but due to falling gross emissions, the uptake has increased substantially relative to gross emissions.

TABLE 1 CHANGE IN CO_2 EMISSIONS ACROSS SECTORS, 1990-2019

	Share of gross emissions 1990	Share of gross emissions 2019	Change in emissions 1990 to 2019
Foreign transport	5%	19%	+159%
Local heating	13%	2%	-91%
Waste disposal	5%	2%	-71%
Electricity and district heating	9%	9%	-30%
Industry	29%	32%	-22%
Farming	11%	14%	-9%
Domestic transport	28%	32%	-17%
Other	5%	9%	+35%
Gross territorial emissions (excl. forestry, land use and foreign transp.)	100%	100%	-29%
Forestry and land use change	-51%	-70%	-3%
Net territorial emissions	49%	30%	56%

Data source: Swedish Environmental Protection Agency

Seeing such an uneven development, a natural tendency for policymakers is to focus on 'laggards' where the transition is slower. In Sweden, a particular focus has been on domestic transportation, where a sector-specific milestone target of 70% reduction in 2030 relative to 2010 is mandated by law. This implies that the transport sector is required to 'make up' for a previous slow reduction. The milestone target for the transport sector requires emissions to fall by 66% between 2015 and 2030. In the remainder of the ESR sectors – the part of the economy not covered by the EU Emissions Trading Scheme (EU ETS) – emissions need only fall by 8% (Hassler et al. 2020).

The law also mandates that Sweden should be climate neutral by 2045 with milestone targets for 2030 and 2040. There are strict restrictions on how much of the transition to climate neutrality can be achieved by negative emissions, i.e. by uptake in forests, land-use change and carbon capture and storage of CO_2 emitted by burning biofuels.[1] The

1 The interim targets are that emissions from the ESR sectors be reduced by 63% and 75% relative to 1990 in the years 2030 and 2040. Of these, 8% and 2% are the maximum allowed reductions that can come from negative emissions. To reach the climate neutrality target in 2045, a maximum of 15% of negative emissions are allowed.

latter makes up a large part of CO_2 emissions (around a quarter of the size of Swedish gross territorial emissions), but these emissions are not counted in the national targets so capturing and storing would be accounted for as negative emissions.

Many activities cannot do much more in the short run to reduce the use of fossil fuel than cutting production. In the longer run, however, technical change in a general sense is a powerful force for transition (e.g. Hassler et al. 2021). In the transport sector, less emissions in the short run requires less transportation. In the longer run, when there has been time to replace the vehicle fleet and change the fuel system, a transition to climate neutrality neither need be very costly nor require less transportation services.

Reducing the transport system's reliance on fossil fuel requires coordination, in particular within the EU. Developing new types of vehicles involves large economies of scale and is therefore not economically reasonable for at least small and medium-sized countries. Furthermore, the transport system is a network – it should be possible to drive cars and trucks across borders.

A fossil-free transport sector requires a green source of energy to replace the fossil fuel. Producing this is easier in some countries than others. Sweden and Norway are endowed with large hydropower potential and have already transitioned to almost fossil-free electricity production, while others have found it necessary to rely on coal power to this day. A coordinated transition to a climate-neutral transport sector needs to take these constraints into account.

HIGH ABATEMENT COSTS IN TRANSPORTATION

Given that the difficulty of a fast reduction of emissions varies by sector and often requires international coordination, the political focus on the transport sector is costly. A key Swedish policy instrument to reach the transport sector emissions target is mandated blend-in of non-fossil-based fuels into gasoline and diesel. For 2021, the requirements are 6% for gasoline and 26% for diesel. The requirements are gradually increasing to 28% and 66%, respectively, by 2030. The government assumes a cost of SEK 0.08–0.12 per litre of fuel for every percentage point of blend-in due to the higher cost of non-fossil fuels. This corresponds to price of €300-500 per tonne of CO_2 abated, which is around five to eight times the current price of emission rights in the EU ETS and three to five times the current Swedish CO_2 tax of approximately €110/tonne CO_2.[2] However, this may be an underestimate. The Swedish Transport Administration recently increased the value of emissions reductions in its cost-benefit analyses of investments in transportation infrastructure from €110 to €700/tonne CO_2.[3] The previous level corresponded to the Swedish CO_2 tax, while the latter corresponds to the agency's estimate of the marginal

2 Burning a liter of gasoline and diesel produces 2.4 and 2.6 kg CO_2, respectively. Note that the calculation unrealistically assumes that the non-fossil fuel has zero emissions of greenhouse gases.

3 From SEK 1.14 to 7 per kg of CO_2.

cost of the blend-in requirement. The argument for using such values is based on the assumption that the polices introduced by the government show, by revealed preference, the social value of emissions reductions. Furthermore, the Swedish National Audit Office (2019) calculates a cost of €850/tonne CO_2 of emissions reductions for all of the measures that are introduced in Sweden to foster a quick transition to electric vehicles.

The focus on the transportation sector thus implies quite high costs of emissions abatement. At the same time, cheaper emissions abatement exists. The marginal abatement costs in the sectors covered by the EU ETS is determined by the emissions allowance price. Over the last five years, the emission allowance price has increased quite dramatically from around €5 euros to over €50 per tonne. However, this is still an order of magnitude lower than the more expensive measures undertaken in Sweden.

SECTORS WITH LOWER ABATEMENT COSTS

Policymakers interested in making the transition to climate neutrality smooth and with little economic and social repercussions should look for areas and activities with weak incentives for abatement. Most fossil emissions in Sweden are priced, either through the EU ETS or the Swedish CO_2 tax that has been broadened substantially over time. Given the pressure created by these prices, decisions by individuals, firms and government agencies are steered to exploiting low-hanging fossil abatement fruit. However, there is substantial potential for relatively cheap negative emissions.

As seen in Table 1, the uptake of CO_2 in forests and land is as large as 70% of gross emissions. This uptake occurs despite no economic incentives at all. The potential for increased uptake at low cost is likely large but requires economic incentives to be exploited. Furthermore, since the incineration of biomass is exempt from both the Swedish carbon tax and from the EU ETS, there is an excessive incentive to burn biomass for heat and electricity generation. Given a carbon content of 50% in wood, exemption from the Swedish CO2 tax corresponds to a subsidy for burning wood equal to around €100/tonne. Without that subsidy, it appears likely that more of the output from the forestry sector would be used for purposes where the carbon does not enter the atmosphere. This can be done by using the output as construction material and also by installing carbon capture and storage (CSS) facilities at combined heat and power plants.

The potential for CCS is large in Sweden. CO_2 emissions up to an amount equal to approximately half of Swedish gross emissions of greenhouse gases could be sequestered if the 27 industrial plants with the largest emissions were equipped with CCS technology. Around 60% of these emissions are from biofuel, where the incentives for sequestration are zero. This is understandable given the political decisions that negative emissions will help only to a very limited extent in reaching the national climate goals. From a climate perspective, it makes no sense.

For the 40% of emissions from the 27 plants that are of fossil origin, the incentive for sequestration is given by the EU ETS price. With existing technologies and using Norwegian storage facilities, the total costs of such CCS is estimated to around €100 per tonne CO_2 (Hassler et al. 2020). Thus, while the current EU ETS price is too low for CCS to be privately worthwhile, CCS is cheap relative to many other measures undertaken.

AGGREGATE CONSEQUENCES AND POLICY CONCLUSION

It is clear that Swedish climate policy leads to highly dispersed marginal costs of abatement. This is due to a plethora of different, partially overlapping polices with subsidies, taxes, other regulations and the restrictions against using negative emissions and financing emissions reductions abroad. The consequences of this for the total cost of the transition to climate neutrality is not immediate to calculate since it depends not only on observed marginal costs differences but also on how elastic these are to changes in abatement. NIER (2017) uses a general equilibrium model where these elasticities are calibrated to show that the cost of reaching the same climate target for 2030 is more than four times higher in terms of lost GDP if all emissions reductions are achieved by direct abatement of domestic use of fossil fuel than if also using negative emissions and financing of foreign reduction and still abiding by EU's rules under the effort-sharing regulation.

Swedish climate policy is based on various targets at different sectoral and regional levels. The structure, with overlapping prices, subsidies and quantity regulations, makes it difficult to assess climate effects and costs. This is not a good role model for the world. Climate policy should instead aim for a simple transparent system for pricing emissions as equally as possible across sectors. The transition to climate neutrality may also require other policy instruments to handle market failures and unintended distributional consequences of emissions pricing. Such polices should be separated from emission pricing and be separately motivated.

The European Commission has recently proposed the introduction of an emissions trading system for the transport and residential sectors. If implemented, this would be a key step towards creating a system where markets get the right signal to choose low-hanging fossil abatement fruit. At the same time, it would give the EU a much better control over aggregate emissions. It will make national emission targets redundant and reduce member states' control of national emissions. That is a price worth paying. After all, climate change is driven by aggregate emissions – where they occur is irrelevant.

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CHAPTER 18

Low-hanging fruit in climate policy: The case of Poland

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LOW-HANGING ABATEMENT FRUIT AND THE TRANSITION TO CLIMATE NEUTRALITY

Earlier this year, the Polish Ministry of Climate and Environment announced its Strategic Plan to decarbonise the energy sector by 2040. The following indicators will be used to track its progress: (1) reducing the share of coal in electricity generation to 56% in 2030; (2) achieving 23% renewable energy in gross final energy consumption in 2030; (3) carrying out new investments in nuclear power stations between 2033 and 2036; (4) reducing CO_2 emissions by 30% by 2030 in relation to 1990; and (5) reducing energy use by 23% by 2030 in relation to the 2007 forecasts.

The proposed policy package raises concerns regarding the overly slow pace of decarbonisation of the Polish economy, especially with respect to the intended dominance of coal. I see the following climate policies that are cost-effective and can have a more immediate impact on the reduction of carbon dioxide emissions: (1) subsidies for turning in 'old' fuel-inefficient vehicles in place of current support for electric cars; (2) a consistent legal and regulatory framework for distributed energy; and (3) coal boiler phase-out.

THE REJUVENATION OF THE VEHICLE FLEET

Total CO_2 emissions in 2017 were 336.6 million tonnes, with the two main emitters being the energy industry (48%) and the transport sector (19%) (KOBiZE 2019a). Subsequently, one of the pillars of the Polish Strategic Plan involves electrification of the transport sector. The discussions focus mostly on public transport, but it is passenger cars that emit the most emissions (almost 70%) (Rabiega at al. 2019). Recently, a subsidy has been introduced for the purchase of electric passenger cars. Although needed, the policy is unlikely to substantially reduce CO_2 emissions due to the specific structure of electricity production and of the Polish vehicle fleet.

1 I would like to thank Zbyszek Bohdanowicz, Jan Witajewski and Tomasz Zylicz for their helpful comments and suggestions.

As of today, electrification of transport would imply the substitution of gasoline for coal in electricity production. Moreover, Poland has the highest share of 'old' passenger cars (i.e. 20 years or older) among the EU member states, at over 35%.[2] The scrapping policies introduced in Western Europe, combined with low personal incomes in Poland during the economic slowdown, resulted in the import of 11 million cars between 2004 and 2018. The majority of these imported cars were over ten years old (Kolsut 2020). Meanwhile, the CO_2 emissions from the transport sector more than doubled between 1990 and 2013 (Benalcazar et al. 2016). Some countries in the Eastern bloc have introduced bans on imports of 'old' vehicles; Poland is not one of them. In 2016, the government attempted to introduce a tax on imported cars, but it backed away from it. Another attempt to regulate markets for imported cars was ruled out by the European Court of Justice as unjustified on the basis that a similar policy has not been imposed on domestic cars already registered in Poland.

The potential for emissions reductions in the transport sector is high. Policies regulating the ownership of fuel-inefficient vehicles may be more effective in reducing CO_2 emissions than subsidies for electric vehicles at present in Poland. A ban on imports of old cars not meeting specific environmental criteria, or a progressive registration fee depending on vehicle age or engine capacity/fuel efficiency, could shift purchases towards newer, more fuel-efficient cars. Other policies that have proven successful in other countries involve a subsidy for trading in vehicles older than nine years. There are concerns that such measures would increase transport poverty, which poses a serious problem in rural areas. But looking at places such as the capital of Poland, with its well-functioning public transport, is disturbing. The GDP per capita of Warsaw is close to that of Berlin but Warsaw averages 727 cars per 1,000 residents, which is twice as many as Berlin. Given the spatial distribution of socioeconomic inequalities in Poland, there is a need for a progressive climate policy, differentiated at the municipality level.

CONSISTENT SUPPORT FOR RENEWABLE ENERGY

The Distance Act entered into force in 2016. It bans the installation of wind power plants within a distance of ten times the height of the windmills from a residential property. Given the current technology and the distribution of housing in Poland, the policy has excluded almost 99% of the country's surface from new wind projects. There is an ongoing discussion on replacing this '10H rule' with a '5H rule', which would shorten the radius of the protected area by half. Liberalisation of the act is necessary. Introducing compensation payments for neighbours of wind farms, who would suffer a loss of property value due to their proximity to wind turbines, could lessen the social impact of, and resistance to, the policy.

2 https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Passenger_cars_in_the_EU#Highest_share_of_passenger_cars_over_20_years_old_in_Poland

The Distance Act has contributed to Poland lagging behind in cutting greenhouse gas emissions and meeting its renewable energy targets for 2020. There has also been a slow increase in micro-generation renewable systems, another source of unrealised emissions reductions. Over the last ten years, about 460,000 micro-generators have been installed in Poland, which has the potential for 4 million. Feed-in-tariffs and premiums, subsidies, tax incentives and preferential loans already exist to support investments in micro-renewable installations. Yet, their uptake has been slower than expected. Barriers to deployment of renewable energy include market and policy uncertainty and technical challenges. For instance, in the past, retroactive policy measures affected the costs of financing of renewable energy, which disincentivised consumers from investing in photovoltaic (PV) projects. As another example, the auction system constitutes the main policy support for renewable energy. Auction schemes should be published three years in advance, but this has almost never been the case. Unclear and unspecific laws have been suggested as a barrier for the development of energy clusters, which are communities of producers and users of renewable energy that help their members minimise distribution and production costs (Dragan 2020). Finally, the existing network infrastructure for transmission and distribution requires modernisation. Its deteriorating technical conditions have resulted in an increasing number of grid access refusals. A stable regulatory framework would help develop long-term policy support and annual renewable targets, taking into account energy prices.

COAL BOILER PHASE-OUT

Poland has the largest share of cities in violation of the EU's 2020 air quality target, reaching 72%. A large proportion of low-stack emissions comes from burning fuel for residential heating. In particular, the household sector is responsible for 46% of emissions of primary PM2.5 particulate matter (KOBiZE 2019b). Although households emit only small amounts of pollutants individually, the total amount of harmful particles, especially in highly dense areas, is significant. During winter, odour from burning coal for domestic heating is omnipresent, interfering with everyday outside activities due to its toxicity. Policies to tackle this problem could generate co-benefits of reducing both local and global emissions. In particular, the housing sector in Poland emits about 30 million tonnes of CO_2, 38% of particulate matter and 80% of carcinogenic benzo(a)pyrene emissions annually (Zysk et al. 2020). Thermal insulation, combined with boiler replacement, could halve CO_2 emissions and eliminate low-stack emissions from domestic heating (Institute of Environmental Economics 2015).

A 'Clean the Air' programme has been introduced, with a budget of €25 billion between 2018-2029, to subsidise the replacement of fuel inefficient boilers. During the first three years of the programme, however, only 10% (i.e. 70,000) of the intended 700,000 boiler replacements for this period have been realised. About 16% of subsidies were granted for installing new coal boilers, followed by investments in gas (45%). Subsidies for coal-fuelled boilers will no longer be allowed under the scheme from next year onwards, while from 2024 the installation of new coal boilers will be banned. Since the average lifespan of such boilers is 10-15 years, this means that home heating with coal will continue for the next 20 years. It has been estimated that the economic costs in Poland associated with disease and premature death from exposure to small PM2.5 is about $40 billion per year (Piñerúa 2019), which is more than the entire cost of the ten-year programme. This calls for banning coal in domestic heating immediately.

Second, subsidies cover on average 30% and 60% of the total eligible expenses for more and less affluent households, respectively. In many cases, poorer households cannot afford to pay the remaining difference. The programme reimburses expenses only afterwards, which is also a barrier for the poorest households. About 18% of households in 2017 were classified as 'energy poor' (i.e. their share of energy expenditure in income was more than twice the national average) (Kielczewska et al. 2019). A programme is needed under which boilers are provided free of charge to the poorest households and/or which would allow low-income households to pay for the initial investment through small instalments over an extended period of time.

Third, low interest in the programme has been observed among households who can afford the expenses and would potentially be interested in the subsidy, but do not apply for it. Their hesitancy could be a result of consumer myopia. A boiler replacement involves substantial upfront costs, especially if combined with thermal insulation, whereas savings from reduced spending on energy consumption can be realised only in the long run. It has been shown that a 'present bias' causes people to undervalue energy savings in the long run when they purchase energy-using durables. This can be illustrated with an example of consumers choosing fuel-inefficient cars, which often results in higher overall fuel expenses compared to if they had purchased a more expensive, fuel-efficient vehicles (Sunstein 2014). Information campaigns explaining short-term costs and long-term energy savings from boiler replacement and improved thermal insulation could increase participation in the 'Clean the Air' programme.

All in all, Poland has already implemented numerous policies and has formulated long-term strategic goals to support a transition to a low-carbon economy. However, progress in achieving mid-term results has been slow. Many policies have been implemented following the EU directives, but tailoring them to Polish circumstances has been a challenge. This is partially due to a multilevel system of environmental funds distributed at the national, regional, county, and municipal levels (Zylicz 2014), which diffuses the responsibility for achieving specific climate goals. Second, Poland needs to balance multiple objectives, namely, coming under increasing pressure to combat global carbon dioxide emissions while at the same time dealing with 'traditional' sources of pollutions that pose immediate health hazards locally. Third, there is low trust in public institutions and weak civil society, which, together with complex procedural and administrative requirements, may discourage people from participating in climate policy programmes. Finally, equity concerns are important when discussing the optimal policy mix. Within one generation, Poland has moved from being one of the most egalitarian countries in Europe to one of the most unequal (Bukowski and Novokmet 2019). As a result, the fear of being left behind can create resistance to climate policy.

Finally, making the energy data publicly available is necessary to engage the scientific community in policy debates on energy transition pathways. So far, only a few Polish institutions have access to the data, which are not available to independent researchers. This unnecessarily limits policy discussions.

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CHAPTER 19

Climate policy in the broader sustainability context: Joint implementation of the 2030 Agenda for Sustainable Development and the European Green Deal

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INTRODUCTION

The United Nations 2030 Agenda for Sustainable Development (United Nations 2015), including its 17 Sustainable Development Goals (SDGs), was adopted in September 2015 by the international community at the UN Sustainable Development Summit. A few weeks later, in December 2015, the Parties to the United Nations Framework Convention on Climate Change (UNFCCC) came together at the 21st Conference of Parties (COP21) in Paris to deliver a landmark agreement[2] to combat climate change and to intensify action for a sustainable low-carbon future. Both the SDGs and the Paris Agreement called for deep transformations in every country and required complementary actions by governments, civil society, scientists, and businesses. While significant progress has been made on some goals, no country is currently on track towards achieving all of the SDGs.

Being a pioneer in climate policy, the EU has capitalised on the above-mentioned initiatives by introducing the European Green Deal (EGD) (European Commission 2019) in December 2019 to reach the goal of climate neutrality by 2050. The EGD offers a comprehensive framework for decarbonising the economy, reducing pollution and waste, and placing sustainable development and the SDGs at the centre of the European policy agenda. The EGD identifies nine areas of intervention: biodiversity, food systems ('from farm to fork'), sustainable agriculture, clean energy, sustainable industry, building and renovating, sustainable mobility, eliminating pollution, and climate action. In line with the EGD, the EU adopted the European Climate Law in the summer of 2021, intending to set out the conditions for an effective and fair low-carbon transition, and to provide

1 This chapter is based on the report *Transformations for the Joint Implementation of Agenda 2030 for Sustainable Development and the European Green Deal: A green and digital, job-based and inclusive recovery from the COVID-19 pandemic*, published by the UN Sustainable Development Solutions Network. The full report is available here.

2 https://sustainabledevelopment.un.org/frameworks/parisagreement

predictability for investors. EU leaders have also decided to integrate the SDGs in the European Semester, which is the major process for the coordination of national economic and employment policies in the EU, thereby deciding to "put people and the planet at the centre of EU economic policy".

While these initiatives were in development, the Covid-19 pandemic hit in February 2020. It is much more than a health crisis – it has had a tremendous socioeconomic impact around the world, the scale of which is still hard to assess. The measures that can help solve the health crisis aimed to "flatten the curve of the pandemic" but, inevitably, they steepened the macroeconomic recession curve and put in danger all supply chains. In response to this crisis, EU leaders agreed in the summer of 2020 to spend a total €1.8 trillion, including the enhanced 2021–2027 EU budget and the Next Generation EU recovery facility, to help Europe recover from the coronavirus pandemic.

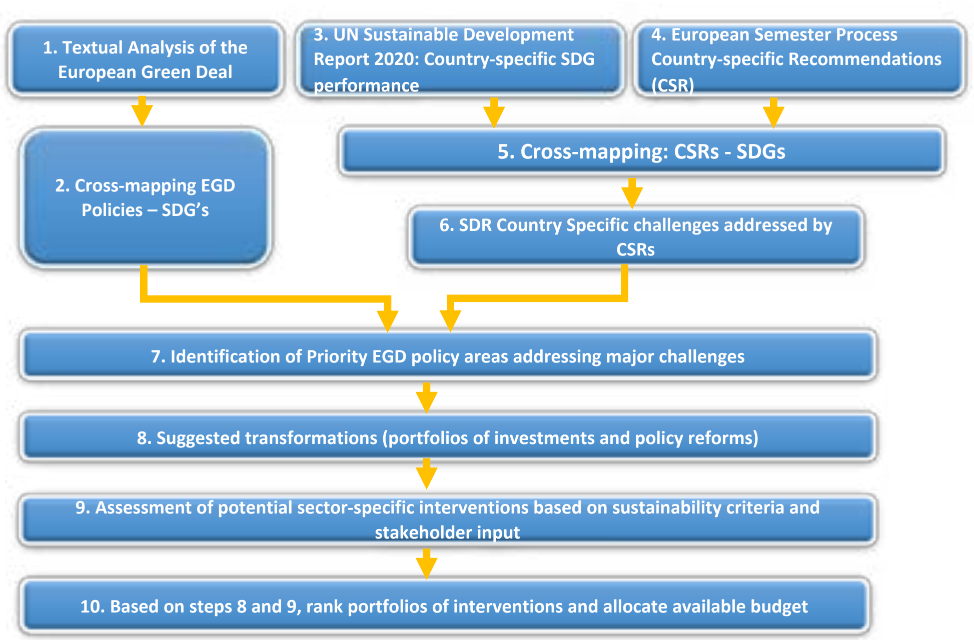
This chapter summarises the findings of a broader study that attempted to connect the dots between these four major policy initiatives – the SDGs, the European Green Deal, the European Semester, and the EU recovery plan – with the aim to support policymakers with actionable strategies that can guide EU-wide economic recovery in line with the continent's overarching sustainability agenda (SDSN 2021). Section 2 helps policymakers make sense of the different policy initiatives by identifying relationships and discrepancies between these policy frameworks in a systematic manner. Section 3 outlines technological and investment pathways to attain climate-neutral and circular economies in Europe. As the green transition requires proactive action by governments towards transformational spending and investments, Section 4 describes the role that 'patient' finance can play and provides examples of novel financial and fiscal policies that have been applied at national and regional level. Section 5 provides policy insights on jobs- and skills-related aspects to make the green transition inclusive and just, which is emphasised by modelling evidence of Section 6 on the distributional impacts of decarbonisation policies.

CONNECTING THE EUROPEAN GREEN DEAL AND EU ECONOMIC POLICY WITH SUSTAINABILITY

This section presents the findings of a '3D mapping' exercise which aimed at integrating the SDG framework both in the European Semester's Country-Specific Recommendations (CSRs), as foreseen in the EU's Annual Sustainable Growth Strategy (ASGS), and in the policies envisaged by the European Green Deal, thereby assisting EU and national policymakers to identify actionable policies, aligned with all overarching frameworks mentioned above.

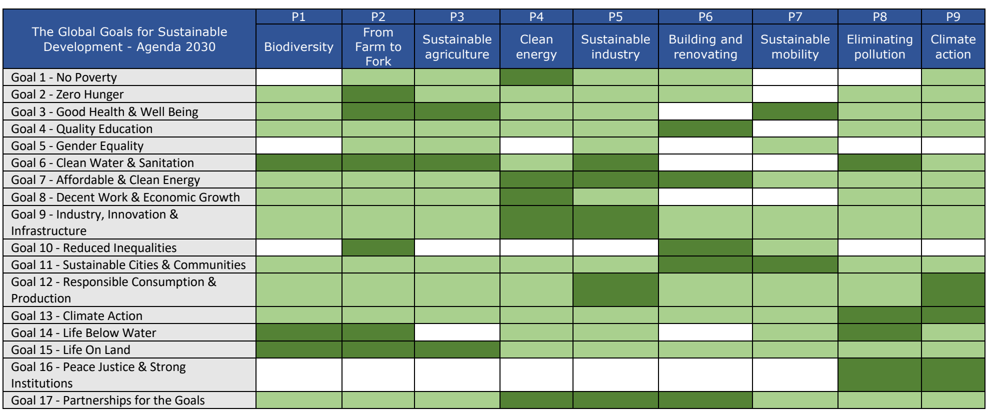
Figure 1 provides an overview of the methodology. The first step was a textual analysis on the main EGD policy document that described the EU's vision for sustainability. Then, in step 2, a more detailed text mining exercise was conducted on the EGD document to match specific parts of it to SDGs that are explicitly relevant. This led to the identification of linkages between each SDG and specific EGD policies, as illustrated in Figure 2.

FIGURE 1 FROM THE THREE FLAGSHIP INITIATIVES (SUSTAINABLE DEVELOPMENT GOALS, EUROPEAN GREEN DEAL AND EUROPEAN SEMESTER) TO TARGETED NATIONAL INTERVENTIONS: FLOWCHART OF THE 3-D MAPPING METHODOLOGY



Source: SDSN (2021).

FIGURE 2 MAPPING OF THE EUROPEAN GREEN DEAL'S POLICIES TO THE 17 SDGS



Notes: Dark green cells denote a direct linkage between EGD Policies and SDGs; light green cells depict the implicitly derived association between EGD policies and the SDGs; white-coloured cells indicate a weak or no apparent connection.

Source: SDSN (2021).

Step 3 involved the collection of country-specific assessments of SDSN's Sustainable Development Report (SDR) (SDSN and IEEP 2020). The UN has established 231 unique performance indicators in total, but a subset of 115 of these is used for the relevant assessment of European countries. In parallel, the corresponding CSRs of the European Commission were collected in Step 4. As part of the European Semester Process, the European Commission annually assesses the performance of every Member State against specific targets related to healthcare, employment, environment, digitalisation and structural reforms, and publishes a report with its findings along with specific recommendations for improvement. Then, since each CSR can be associated with some of the SDG indicators, step 5 connected the relevance of the sustainability performance indicators mentioned in step 3 with the outcome of CSRs of step 4.

Next, in step 6, the analysis focused on the most problematic policy domains by country – i.e. those which the SDR has identified as presenting 'Major' or 'Significant' remaining challenges – and examined whether these are addressed by the CSRs. Results indicated that several of the 115 SDR performance indicators cannot be found in any CSR. This suggests that the CSR process is not efficiently capturing all sustainability challenges within EU countries. Finally, step 7 combined the mapping of SDGs to EGD policies described in step 2 with the mapping between CSRs and Major/Significant Challenges for each country that was performed in step 6. Policies associated with 'Major Challenge' SDGs were prioritised and followed by policies in domains associated with SDGs under the label of 'Significant Challenges'.

Steps 8 to 10 follow the 3D mapping in order to move to country-specific interventions, identify synergies and trade-offs between sectors, evaluate the most promising interventions through a wide range of sustainability criteria, and rank them through a composite score that weighs the views of stakeholders and the relative importance of each criterion. Policymakers can use this ranking to proceed with a list of priorities for policies, investments and reforms in each economic sector and – to the extent that they involve public funding – allocate the available public budget to individual interventions.

The methodology outlined above leads to three useful policy conclusions with EU-wide significance. First, 'Major Challenges' for most of the EU27 Member States can be found in the policy domains of SDGs 12, 13, and 14, whereas most of the 'Significant Challenges' (i.e. challenges of slightly lower priority) are related to SDGs 2, 5, and 9. Second, it turns out that the EU macroeconomic policy coordination process (the European Semester and its CSRs) is quite efficient in addressing the EU sustainability challenges, but there is room for further improvement. As shown in Table 1, the European Semester monitoring procedure has captured 70% of the weaknesses identified by the UN Sustainable Development Report. Third, the analysis allows to prioritise the implementation of the nine EGD policy areas; this is demonstrated in Table 2, which indicates that policies expected to yield the highest impact on most countries are policies P2, P5, P8, and P9, i.e. those associated with an environmentally friendly food system ('from farm to fork'), sustainable industry, the elimination of pollution, and climate action, respectively. Table 2 demonstrates how the EU strategy is translated to country-specific policy priorities.

TABLE 1 THE EUROPEAN SEMESTER (CSRS) IS QUITE EFFICIENT IN IDENTIFYING SUSTAINABILITY CHALLENGES OF EU MEMBER STATES: OUT OF 459 CASES (17 SDGS X 27 COUNTRIES), 321 CHALLENGES HAVE BEEN SUCCESSFULLY ASSESSED BY CSRS

SDG's assessment category	Addressed by CSR	NOT addressed by CSR	Total
Achieved	21	24	45
Challenges Remain	120	46	166
Significant Challenges	115	44	159
Major Challenges	64	20	84
Grey (not available info)	1	4	5
Grand total	**321**	**138**	**459**
Ratio	**70%**	**30%**	

Source: SDSN (2021).

TECHNOLOGICAL AND INVESTMENT PATHWAYS

In late June 2021, the European Parliament approved the European Climate Law to make the EU's greenhouse gas emissions targets legally binding, paving the way for a policy overhaul to cut planet-warming pollution faster. The bill sets targets to reduce net EU emissions by 55% by 2030, from 1990 levels, and eliminate net emissions by 2050 (Abnett 2021). This section draws on insights from recent research (SDSN and FEEM 2019) to provide EU policymakers with a set of technological and policy insights that they could consider while designing the EU's long-term trajectory to climate neutrality by 2050, with an emphasis on the low-hanging fruit among these policy options.

TABLE 2 TRANSLATING THE EUROPEAN GREEN DEAL TO NATIONAL PRIORITIES: PRIORITISATION OF EGD POLICIES FOR EACH EU27 MEMBER STATE

Prioritization of EGD Policies for each Country. A - High Priority B - Next Priority Blank - Not relevant	P1	P2	P3	P4	P5	P6	P7	P8	P9
	Biodiversity	From Farm to Fork	Sustainable agriculture	Clean energy	Sustainable industry	Building and renovating	Sustainable mobility	Eliminating pollution	Climate action
Austria	B	B	B	A	A	A		A	A
Belgium	A	A	B	B	A	B		A	A
Bulgaria	B	A	B	B	B	A	B		B
Croatia		A		B	B	A	B	B	B
Cyprus	B	B		A	A	A	B	A	A
Czech Republic	B	B	B	A	A	A		A	A
Denmark	A	A			A	B	B	A	A
Estonia		A	B	B	A	B		A	A
Finland	B	B		B	A	B		A	A
France	B	B		B	A	B		A	A
Germany		B			A			A	A
Greece	B	B	B	B	B	B	B	A	A
Hungary		A	B	A	A	B		A	A
Ireland	B	B		A	A	A		A	A
Italy	A	A	B	A	A	B	B	A	A
Latvia	A	A	B	A	A	A	B	A	A
Lithuania	B	A	B	A	A	A	B	A	A
Luxembourg	B		B	A	A	A	B	A	A
Malta	A	A	B	A	A	A		A	A
Netherlands	A	A	B	A	A	A		A	A
Poland	A	A		A	A	A		A	A
Portugal	A	A		B	B	B		A	A
Romania	A	A	B	B	B	A	B	B	A
Slovak Republic		A		A	A	B		A	A
Slovenia	A	A		B	A	B		A	A
Spain		A						B	B
Sweden		B			A			A	A
High Priority for # of Countries:	10	17	0	13	21	13	0	23	24
Next Prority for # of Countries:	10	9	14	10	5	11	10	3	3

Note: A: High Priority, B: Next Priority, Blank: Neutral.

Source: SDSN (2021).

The European Green Deal should be conceived on a 'systems approach' aiming to address multiple objectives simultaneously and promoting policy instruments and technological solutions that can be used across many sectors. The multiple objectives span decarbonisation and environmental sustainability, economic prosperity, and social inclusion. Policy instruments include public investments, the phase-out of subsidies to fossil fuels, market mechanisms, regulatory frameworks on energy and land use, and targeted R&D. Technological solutions include a wide range of existing and emerging technologies, from 5G-enabled and AI-empowered smart power grids to synthetic fuels produced with renewable energy. We identify several key complementarities for managing the complexity of the energy system and six main pillars for decarbonisation:

1. Zero-carbon electricity: A shift towards a zero-carbon electricity mix.
2. Smart power grids: Systems able to shift between multiple sources of power generation and various end uses to provide efficient, reliable and low-cost systems operations, despite the variability of renewable energy.
3. Electrification of end uses: The penetration of electricity, built on existing technologies, can enable a green conversion for the sectors currently using fossil-fuel energy.
4. Materials efficiency and circular economy: Improved material choices and material flows, such as 'reduce, reuse, and recycle', to significantly improve materials efficiency.
5. Green synthetic fuels: Deployment of a wide range of potential synthetic fuels, including hydrogen, synthetic methane, synthetic methanol, and synthetic liquid hydrocarbons applicable for harder-to-abate sectors.
6. Sustainable land use: Mainly involving the agriculture sector, as it contributes up to a quarter of all greenhouse gas emissions from deforestation, industrial fertilizers, livestock, and direct and indirect fossil fuel uses.

With the exception of green fuels, which require a longer time horizon and large investments to get to the market (as a first step, 'pilot scale' projects aspire to attract ESG funds in order, as a next step, to enlarge their capacity), all other pillars present a number of low-hanging fruit that can be immediately pursued by policymakers. Energy efficiency measures are very cost-effective and require access to finance and targeted subsidies to materialise; smart grids can enable the fast penetration of low-cost renewable electricity; several circular economy options are cost-effective and need awareness-raising and training of businesses as well as targeted incentives; and sustainable land use can yield fast benefits to both climate change mitigation and adaptation. There are further no brainers among climate change adaptation measures – according to the World Bank (2020), investments in climate-resilient infrastructure offer on average four dollars of benefit for each dollar invested.

To reach climate neutrality by 2050, the EU will have to transform its power, industry, transport, and buildings sectors, completely abating their greenhouse gas emissions. Tables 3 and 4 outline national actions required in the regulatory and financial domain, which enabled by global developments, can lead to the zero-carbon transition.

TABLE 3 NATIONAL EFFORTS AND GLOBAL ENABLERS TO REACH ZERO NET EMISSIONS BY 2050

Six pillars to zero net emissions by 2050	National actions	Global enablers
Zero-carbon electricity	Zero-carbon electricity grid, mainly based on renewable energy.	Reduced costs of renewable energy, mass scale-up of solar photovoltaics and wind turbines, improved energy storage technologies and expanded R&D of new energy sources.
Smart power grid	Introduction of a digital power grid and the Internet of Things (IoT).	R&D of artificial intelligence (AI)-backed smart grid systems.
Electrification	Infrastructure for battery electric vehicles, retrofitting of buildings for electric heating and cooking.	Global phaseout of ICE vehicles, global mass production of battery electric vehicles (BEVs).
Materials efficiency and circular economy	Introduction of the circular economy and national waste management systems	R&D of alternatives to cement, plastics, and other pollutants (persistent pesticides).
Synthetic fuels	Infrastructure for trade and distribution of synthetic fuels and biorefining.	Global R&D and scale-up of synthetic fuels for heavy-duty vehicles, ocean shipping, aviation, heavy industry.
Sustainable land use	Sustainable land-use regulations (reforestation, restoration of degraded lands), precision agriculture, reduced food wastage, a shift towards plant-based protein diets.	Sustainable global supply chain management for major crops, global real-time monitoring systems for land management.

TABLE 4 MAJOR FISCAL AND FINANCIAL POLICIES FOR ZERO-EMISSION POLICIES

Action area	Major fiscal and financial policies
Zero-carbon electricity	Regulatory framework for power grid operators; public investments in renewable energy transmission and distribution; income support for fossil fuel-producing regions and sectors experiencing social costs of transition; redesign of electricity markets; financial market regulations to avoid stranded assets in the financial system; carbon pricing and taxation; green bonds.
Smart power grid	Public investments in digital technologies for the power grid; regulations on AI and big data; design of IoT.
Electrification	Public investments in infrastructure (e.g. charging facilities for BEVs); building codes for zero-emission buildings; regulations for phasing out ICE vehicles (coupled with incentive schemes to address equity issues); public procurement of BEVs; retrofitting and design of public buildings.
Materials efficiency and circular economy	National and local regulations on waste management and recycling; policies for waste valorisation.
Synthetic fuels	R&D outlays for synthetic fuels; public infrastructure for synthetic fuels (e.g. adaptation and upgrading of existing pipelines for hydrogen, e-fuels, etc.), regulation to ensure ethical sourcing of biomass. These fuels should be generated by RES and may require 5 to 6 times more RES electricity units to generate one unit of synthetic fuel.
Sustainable land use	Land-use regulations; public investments in national land-use monitoring systems and enforcement mechanisms; public payments for ecosystem services (e.g. payments for protected areas); green bonds.
International cooperation and investment allocation	Result based Investment for all public aid at a bilateral and multilateral level, national support to de-risk private investment for the energy transition.

In the field of energy efficiency, the Commission's assessment of the final NECPs shows that the aggregated ambition would amount to a reduction of 29.7% for primary energy consumption and 29.4% for final energy consumption (compared to the projections of the 2007 Reference Scenario), reaching 1176 Mtoe and 885 Mtoe, respectively, in 2030. Despite the fact that the collective ambition for 2030 has been increased compared to the draft plans, a gap still remains compared to the Union's 2030 target of at least 32.5%. Most final NECPs set out only limited details on the application of the energy efficiency first principle. In the building sector, the NECPs include various energy efficiency measures with regard to building renovation. As the targets of the NECPs are insufficient to achieve the EU's energy efficiency target for 2030, the Commission has published the "Renovation

Wave for Europe" and the "Recommendation on Energy Poverty". Final and primary energy consumption would have to decrease to around 39–41% and 36–37%, respectively, to achieve at least 55% greenhouse gas emissions reductions.

THE ROLE OF PATIENT FINANCE AND FISCAL POLICY IN THE COVID RECOVERY

The global economy has been significantly disrupted by Covid-19 and governments need to make significant and long-term investments to support rapid recovery from the shock. This section explores the role of patient finance and novel fiscal policies related to the green transition – many of which are really low-hanging fruit and can be vigorously pursued without delay.

Europe's economy was fragile even before Covid-19, not having recovered from the 2008 crisis. European countries continue to have different levels of competitiveness, often due to different levels of investment in key drivers of growth, such as education, R&D, and skills, so a new action plan that looks at both the rate of growth and its direction is needed (Mazzucato et al. 2020). The Next Generation EU (NGEU) Recovery Package can contribute to this new direction as it supports the reorientation of activity towards innovation for resilience and requires member states to prioritise green, digital, and healthcare investment.

Finance is not neutral (Mazzucato and Semieniuk 2018). The private financial sector often tends towards short-termism and a risk-averse approach, but sustainable innovation requires patient, long-term, strategic finance. Only when there is a stable and consistent direction for investment will regulation and innovation converge along a green trajectory (Mazzucato and McPherson 2019). Considering patient finance in the EU, seven years – as provided for in the EU's budget – may be a significant time horizon compared to other short-term funding mechanisms, but not long-term by the standards of truly 'patient' finance, which is needed for transformative change. We therefore need to ensure that a portfolio, multi-pathway approach is taken to investment and that each route is supported across the innovation chain. This would allow for opportunities, from basic research through to full deployment, and from general purpose technologies through to highly specialised design, to flourish. This requires finance that is risk-welcoming and dependable, and that is able to absorb the possibility of failure.

An ecosystem of public finance and public policy is needed to direct the European economy towards a sustainable direction and to actively 'tilt the playing field' in favour of sustainable activity. For this purpose, an alignment is required between multiple financial institutions at the macroeconomic (monetary and macroprudential policy), mesoeconomic (long-term finance from public financial institutions), and microeconomic (firm) policy level. At the macro level, there has recently been a welcome emphasis on how climate-related financial risks may impact central banks' established financial stability mandates (Kedward et al. 2020). At the 'meso' level, national public investment organisations provide positive sources of long-term patient finance, which can support sustainable investing. In this context, the European Investment Bank and the European Investment Fund will play a vital role in post-pandemic recovery, particularly for companies that are increasingly indebted in the crisis.

There is no shortage of money; the innovation gap is in direction-setting for the money that is being placed at the disposal of NGEU. The SDGs can and should be drawn on to provide a useful framework for creating conditions on the finances available. Conditionless bailouts in 2008 allowed policymakers to flood the world with liquidity without directing it towards good investment opportunities. Covid-19 relief conditionalities can align with sustainable outcomes and there are differences between 'emergency' liquidity lending, the rapidity of which can make it difficult to attach conditions, and longer-term lending geared towards recovery (McDonald et al. 2020). Conditions can be attached to the latter to ensure that bailouts are structured in ways that transform the sectors they are saving so that they become part of a new economy – one that is focused on lowering carbon emissions while also investing in workers and making sure they can adapt to new technologies. Corporate behaviour must align with long-term societal needs and conditionalities should not be seen as increasing barriers to doing business. Companies that switch direction soonest will be the most competitive, most innovative and most successful over time.

The question faced by the European Union is: What does it mean to govern resilience and recovery policy in a way that drives sustainable development and creates public value? A key place to start from is existing policy. Europe must ensure that the ideas lying around are not its answer to the 2008 financial crisis, such as austerity-led nation-state bailout conditionalities and fractured inter-European relationships, which did nothing to increase resilience to forthcoming shocks. Instead, investment must be based on the carefully and thoughtfully laid policies already laid out in Europe, including the industrial strategy; the European Green Deal, with its pledge to 'leave no one behind'; the Just Transition Mechanism; the work ongoing on the circular economy, biodiversity and the 'farm to fork' sustainable food strategy; and the mission-oriented approach underpinning Horizon Europe that is also being embraced by member states and at the sub-national level. The recent experience of governments working together with industry and managing to get effective coronavirus vaccines within one year shows the direction that should be replicated in the case of zero-carbon technologies.

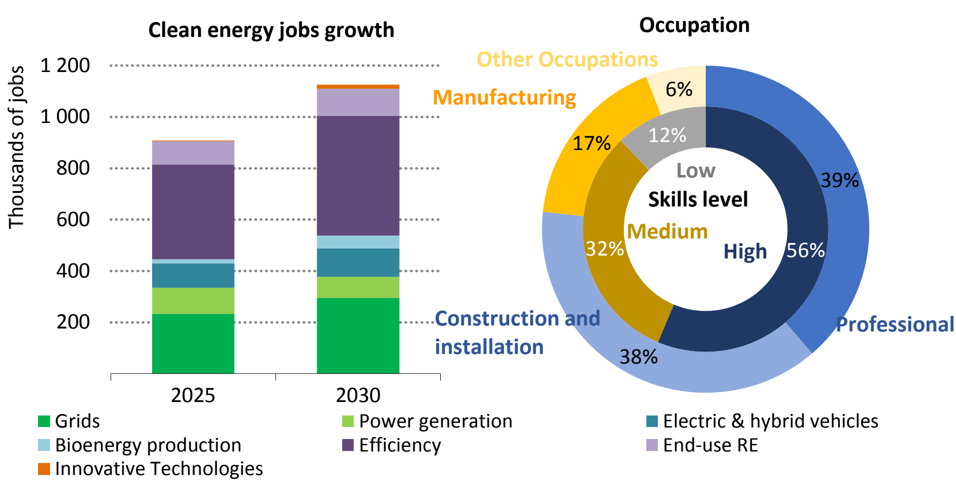
Green financial regulations need to provide a transparent ecosystem in order to satisfy the proper ESG invested products and services, to secure the redistribution of companies' and financial institutions' portfolios in a zero-carbon direction and to prevent 'greenwashing', through clarified regulatory adjustments. The classification of enterprising activities through taxonomy rules is a first step. EU taxonomy could be recognised as a leading initiative in order to provoke similar developments in all regions and continents. Second, the proper information system given to the markets, including pricing of impacts, could enhance the specific redirection of capital flows. Finally, sustainability accounting supports the clear picture and the potential redirection of the green orientation at the company, sectoral and national economy level.

EFFECTS OF THE SUSTAINABILITY TRANSITION ON JOBS AND SKILLS

The Covid-19 pandemic – with the associated hundreds of millions of job losses – has highlighted the need to focus on policies that restore employment while avoiding the exacerbation of global climate change and resource depletion. It has repeatedly been stated that the right investments will need to be labour-intensive in the short run and have high multipliers and environmental co-benefits (Stern et al. 2020).

Clean energy transitions will have a pronounced impact on energy employment. Europe is one of the leading geographies to commit substantial funds to a sustainable recovery as a part of the European Green Deal Investment Plan (EGDIP). The scale of the investment outlined for the next ten years creates a need for a rapid scaling up of clean energy employment in the region. Accordingly, the IEA has estimated the total job growth in Europe associated with the energy investments and spending in the Sustainable Development Scenario, as shown in Figure 3.

FIGURE 3 NUMBER OF ADDITIONAL EUROPEAN JOBS NEEDED TO SUPPORT AN ADDITIONAL PER ONE MILLION USD OF INCREMENTAL INVESTMENT ANNUALLY



Source: IEA analysis, adapted from a figure in the EIB Investment Report 2020/21.

This rapid scale-up of employment can necessitate a doubling of the current workforce in nascent industries such as electric vehicle production. But even in established segments like electricity networks and power generation, a 30% increase in the workforce would be required in Europe, on top of massive shifts and retraining of the current workforce to work on new segments of a business.

In Europe, clean energy jobs are highly skilled, with over 50% of jobs requiring highly skilled individuals while only around 10% can be filled by untrained manual labour. This underscores the importance of workforce training and retraining. targeting universities, trade schooling, and vocational retraining programmes, which can be a key focus for EGDIP's Just Transition Mechanism. Most roles created would require at least moderate retraining, which could focus on transitioning workers within the same industry from one segment to another or between industries but within the same occupation (e.g. a construction worker being retrained to conduct high-quality building energy envelope investments).

This training could also target those entering the workforce for the first time, as well as addressing asymmetry in the participation of women and other underrepresented communities in the energy industry. A multi-track approach is needed to close gender gaps and achieve equality in employment and remuneration (ILO 2018).

Beyond the energy sector, there is evidence that green economic recovery programmes are not only important for keeping Europe on track for the climate neutrality objective but can also positively affect employment prospects in the continent. Elements of the sustainability transition such as the circular economy, green agriculture and nature-based solutions like restoration of ecosystems and tree planting, which have been less well researched up to now, are also important ingredients of a green recovery plan, as they are expected to yield favourable employment impacts. Green recovery measures may be particularly effective in communities whose workers already have the appropriate green skills (Chen et al. 2020). To quickly reap the benefits of these low-hanging fruit for the green transition, European policymakers will need to adopt interventions that can match labour supply and demand by providing appropriate educational and vocational training to the workforce of vulnerable sectors and regions. The Fourth Industrial Revolution, with its unprecedented pace of technological advancement, calls for governments to invest in life-long learning and focus education systems on 'deep learning', or learning how to learn.

EQUITY CONSIDERATIONS

The costs associated with European decarbonisation policies will need to be minimised and distributed across different sectors to ensure that low-income populations and vulnerable communities do not carry an inequitable share of the financial burden. Recent research (Eurelectric 2020) shows that appropriate countermeasures should be put in place to avoid the increase of inequality and to ensure broader support for the energy transition.

The study identified six decarbonisation policies (carbon pricing, energy taxation, emission performance standards, subsidies for low-carbon technologies, phase-out of the subsidies for fossil fuels and energy efficiency measures) that are needed to achieve EU decarbonisation and simulated them through a macroeconomic model, analysing the patterns of income inequality up to 2050 in Europe (EU27 and the UK) and its macro-regions. Some policies will result in lower-income households benefiting financially more than other income groups (a progressive effect), while others will result in lower-income households being disproportionately burdened by costs (a regressive effect). If all key decarbonisation policies were implemented without proper countermeasures, the overall effect would be regressive.

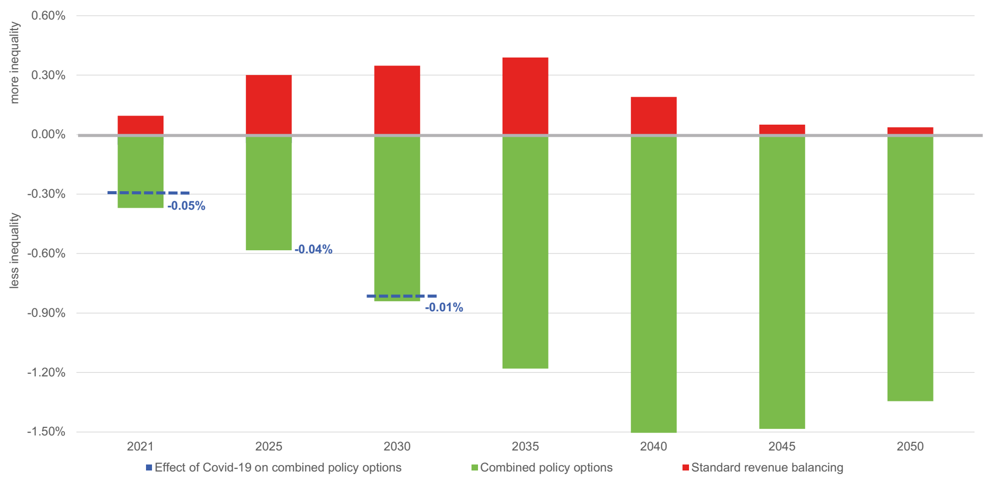
As a second step, a menu of policy options that can effectively reverse the regressive effects of decarbonisation policies was added into the modelling and the net distributive impact of a wider combined policy package was assessed. In particular:

- the revenues raised from policies such as carbon pricing can be used to offset reductions in VAT or electricity taxes, or in the alternative, the same revenues can be used for providing lump-sum direct rebates;
- energy efficiency measures can be targeted to low-income groups to ensure future energy savings;
- programmes to reskill and upskill workers, such as the job retraining programmes focused on industrial sectors most affected by decarbonisation, can be important preventive policy options to implement; and
- low-carbon innovative technologies can benefit from subsidies funded via general taxation.

As can be seen in Figure 4, implementing the combined policy options – key decarbonisation policies plus the four mitigation measures mentioned above – is projected to improve equality. The positive effect is expected to grow over time and the difference in the Gini coefficient[3] compared to the standard revenue balancing case is very substantial, especially in the period 2030–2050. Furthermore, sensitivity analysis shows that the measures that were taken to limit the spread of Covid-19 do not have a substantial impact on the distributional effects of climate policies .

3 The Gini index, or Gini coefficient, is an indicator of inequality in terms of financial and social wealth. It measures the distribution of income within a nation or any other group of people and its value ranges between 0 and 1, interpreted as complete equality and perfect inequality, respectively. Thus, an increase in the Gini index expresses a rise in inequality and vice versa.

FIGURE 4 SOCIAL EQUITY IMPROVES IF DECARBONISATION POLICIES ARE ACCOMPANIED BY TARGETED MEASURES TO COUNTERBALANCE REGRESSIVE IMPACTS: GINI INDEX VARIATION FOR COMBINED POLICY OPTIONS IN EU27 + UK BASED ON MODEL SIMULATIONS



The study also provides an estimate of the effect on GDP and employment, and finds that the combined policy package can increase both indicators. In particular, in the short term, the GDP impact is mostly driven by investments in energy efficiency measures; in the longer term, the positive change in GDP increases as emissions performance standards come into effect, reducing consumer prices through energy savings in industry, and reducing fossil fuel imports as road transport will be progressively electrified over time. On the other hand, employment growth until 2035 is dominated by an increase in construction and manufacturing jobs to meet the energy efficiency investment. Over the longer term, the employment growth is concentrated in service sectors and the electricity generation and supply sector. The positive employment effect in the service sectors is driven by an increase in consumer demand due to higher real incomes, whereas in the electricity generation and supply sector, the positive impact is driven by the need to meet the additional electricity demand due to electrification.

Finally, the modelling also suggests that all European macro-regions will benefit from the combined policy options. Southern Europe and Central and Eastern Europe are expected to experience the most benefits in terms of GDP growth and declining inequality, while Western Europe is expected to have a large share of the employment benefits in terms of increased jobs. Northern Europe, on the other hand, shows the smallest economic impact from the various climate policies, largely because a higher level of decarbonisation has already been achieved. To conclude, measures such as revenue recycling, reskilling, and targeted subsidies to low-income groups and innovative technologies are among the low-hanging fruit of the green transition in Europe.

CONCLUSIONS

Covid-related recovery packages are financed by national debt, which means they are loans from future generations. This creates a moral responsibility for the current generation to 'build back better' by investing in the transformation of the current economic, financial, social and political system, which will trigger the exponential change needed to face the climate crisis, economic crisis and the health crisis in a sustainable, resilient and socially inclusive future. The good news is that, in addition to a moral obligation, there is an economic case for 'building back better'. Although all countries are facing a central trade-off over whether they should provide 'stimulus spending' to provide immediate support to maintaining business as usual or provide 'transformative spending' for green and digital economy and inclusive society, recent simulations confirm that a green economic stimulus is more growth-enhancing than a 'return-to-normal' stimulus that would merely boost current, unsustainable consumption and production patterns. Moreover, cleaning unsustainable supply chains and production processes that lead to deforestation and biodiversity threats can help reduce the risk of future zoonotic diseases and pandemics. Investing in climate resilience also reduces the risk of extreme weather events and poverty for hundreds of millions of people.

So far, global financial resources devoted to, and commitments made for, a green recovery are largely insufficient. As mentioned in the Lancet Covid-19 Commission Statement on the occasion of the 75th session of the UN General Assembly (Sachs et al. 2020), one exception is the European Union, where the European Green Deal provides the right level of ambition and direction, and where efforts have been made to align the investment framework with green and digital recovery. Indeed, the European Green Deal contains essentially all no brainers and low-hanging fruit of climate policy; it is up to national governments to implement them. This chapter has provided an overview of the transformations Europe must go through to enable a green and digital, job-based and fair recovery from the Covid-19 pandemic, which will be co-designed by all relevant stakeholders – politicians, policymakers, researchers, innovators, technology developers, businesses, NGOs and civil society. We have identified several of the low-hanging fruit of European climate policy: enabling access to finance for massive renovations that improve energy efficiency; supporting low-cost renewable energy sources through modernisation of electricity grids and incentivising adoption of decentralised renewable electricity; retraining part of the labour force within the same market segments to equip them with the necessary green skills; and chanellling public finance to support business innovation in zero-carbon technologies, nature-based solutions and circular economy investments.

Never waste a good crisis!

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CHAPTER 20

The critical role of feebates in climate mitigation strategies

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RATIONALES FOR FEEBATES

Feebates involve a set of charges levied in proportion to the difference between the emissions intensity of a particular product or activity and the corresponding industry- or market-level emissions rate. For example, if applied to the road transport sector, under a feebate new vehicles would be subject to a one-off fee equal to the product of:

1. a price on CO_2 emissions;
2. the difference between the vehicle's CO_2 per mile and the average CO_2 per mile of the new vehicle fleet; and
3. the average amount vehicles are driven over their lifetime.

And if applied to the power generation sector, generators would be subject to an annual fee equal to the product of:

1. a CO_2 price;
2. the difference between the generator's CO_2 per kilowatt hour (kWh) averaged over their plants and the industry-wide average CO_2 per kWh; and
3. kWh produced by the generator.

Feebates are the fiscal analogue of regulations, for example, that have been commonly applied to the average emission rates of manufacturers' vehicle sales fleets.[1]

Feebates have several key attractions. They promote the full range of behavioural responses for reducing the emissions intensity of a particular sector. In power generation, for example, for all producers they potentially encourage: (1) shifting from coal to natural gas generation; (2) shifting from coal/gas to nuclear; (3) shifting from coal/gas to renewables; (4) adoption of carbon capture and storage at coal/gas plants; and (5) efficiency improvements that lower the amount of coal and natural gas per kWh

1 For a conceptual discussion of feebates, see IMF (2019: Annex 2 and 3).

of generation. In contrast, incentives for renewables only promote the third of these responses. Unlike carbon pricing, however, feebates do not promote a demand response – for example, they do not encourage people to drive their vehicles less.

Another attraction of feebates is that they are automatically cost-effective. This is because, across all the behavioural responses they promote within and across firms, the reward (lower fees or higher rebates) for reducing emissions by an extra tonne is the same. In contrast, emission rate regulations do not automatically equate the cost of the last tonne reduced across different firms – this would require extensive credit trading with firms that go beyond emission rate standards selling credits to other firms that fall short of the standard.

Feebates do not impose a fiscal cost on the government – so long as the average industry or market emission rate in the feebate formula is regularly updated. In contrast, clean technology subsidies impose a fiscal cost on the government – in fact, subsidies can create a tension between environmental and fiscal objectives because the more successful they are in promoting clean technologies the larger is their fiscal cost.

Feebates may also have greater political acceptability than carbon pricing. This is because they do not impose a new first-order tax burden on the average household or firm, and therefore have little impact on energy prices. In contrast, carbon pricing causes significant increases in energy prices as tax revenues, or rents/revenues from emissions allowances under an emissions trading scheme (ETS), are passed forward in higher energy prices. Feebates might be a low-hanging fruit in the sense that they could be easier to scale up than carbon pricing due to less opposition from household and industry groups.

Feebates are also compatible with existing regulations. In fact, feebates provide ongoing incentives for firms to exceed any regulatory standard.

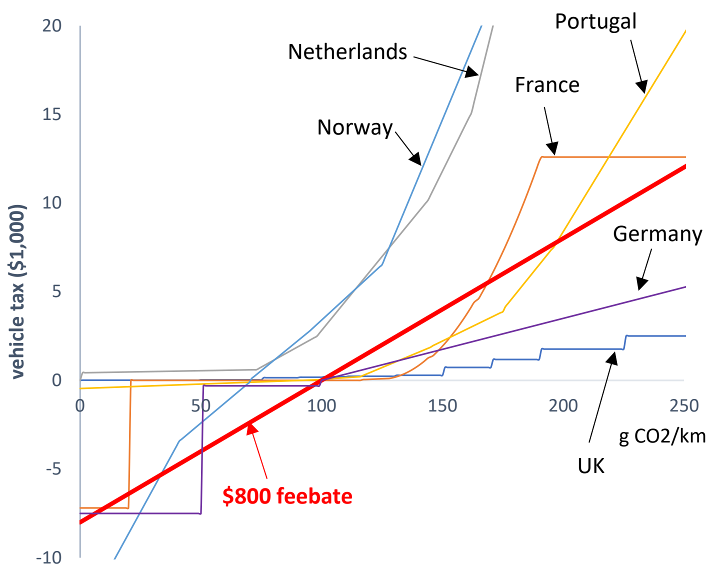
Feebates do not have to be revenue-neutral. For example, a yardstick approach might be used where the pivot point would be based on emission rates for a group of relatively clean firms or products. This would trade off raising a positive amount of government revenue from the feebate against higher energy prices (as this revenue is passed forward in higher prices).

TRANSPORTATION

A number of countries have incorporated elements of feebates into their vehicle registration tax systems, though typically tax schedules are staggered rather than continuous, rates often increase by more than in proportional to CO_2 emissions, and systems are typically not revenue-neutral. Nonetheless, these systems can still provide very powerful incentives to shift consumers to electric vehicles (EVs) or other low- or zero-emission vehicles – in European countries, the implicit carbon price in existing systems is around $800 per tonne or more. These incentives would not be possible to create through higher fuel taxes.[2]

Feebates for the vehicle sector typically do not require new administrative capacity relative to the existing registration fee systems and in this sense are a no brainer – they just require a recalibration of tax rates. And the CO_2 price in the feebate can be adjusted if targets for EV penetration are not being met. Subsidies for EVs would decline over time as the average fleet emission rate declines, which is appropriate as the cost differential between EVs and their gasoline/diesel counterparts falls over time (e.g. with improvements in EV battery technology).

FIGURE 1 CO_2-BASED COMPONENTS OF VEHICLE REGISTRATION FEES, SELECTED COUNTRIES, 2018



Note: Figure shows rebate/fees according to a vehicle's emission rate under a feebate with pivot point of 100 grammes CO_2 per km and price of $800 per tonne of CO_2. Other curves illustrate how vehicle registration fees/subsidies are related to emission rates in other countries.

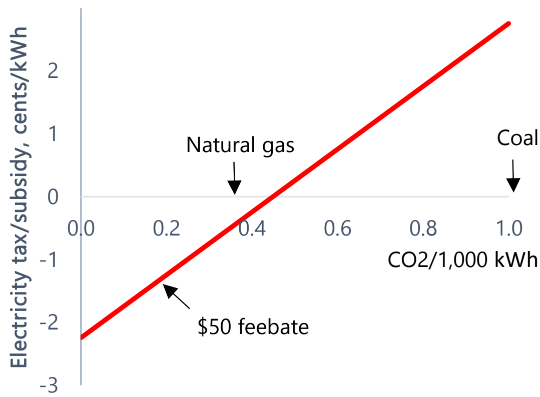
Source: ACEA (2020) and IMF staff calculations.

2 Current gasoline and diesel fuel taxes are typically below the equivalent of $300 per ton of CO2 (OECD 2019).

POWER GENERATION

Feebates for the power generation sector could build off existing procedures for monitoring power company emissions where ETSs are currently applied (e.g. in China, the EU or Korea). For illustration, in the US, where the current emission rate is about 0.4 tonnes of CO_2 per 1,000 kWh, a feebate with a price of $50 per tonne would apply a subsidy of 2.2 cents per kWh for zero-carbon generation plants and a fee of 2.8 cents per kWh for coal plants (Figure 2). Natural gas plants would receive a small initial subsidy, though this would progressively decrease and become a fee (while subsidies for renewables would decline) as the industry average emission rate declines over time.[3]

FIGURE 2 ILLUSTRATIVE FEEBATE FOR POWER SECTOR



Note: Figure shows fees/rebates in cents per kWh applied to generators according to their average emission rate assuming a pivot point of 0.45 tonnes CO_2 per 1,000 kWh and a CO_2 price of $50 per tonne.

Source: IMF staff.

INDUSTRY

Feebates could reinforce incentives for cleaner production processes in carbon-intensive industries like aluminium, steel, cement, chemicals. In this case, firms within an industry would be subject to a fee given by the product of:

1. a CO_2 price;
2. the difference between a firms CO_2 per unit of output and the industry-wide average CO_2 unit of output; and
3. the firm's output.

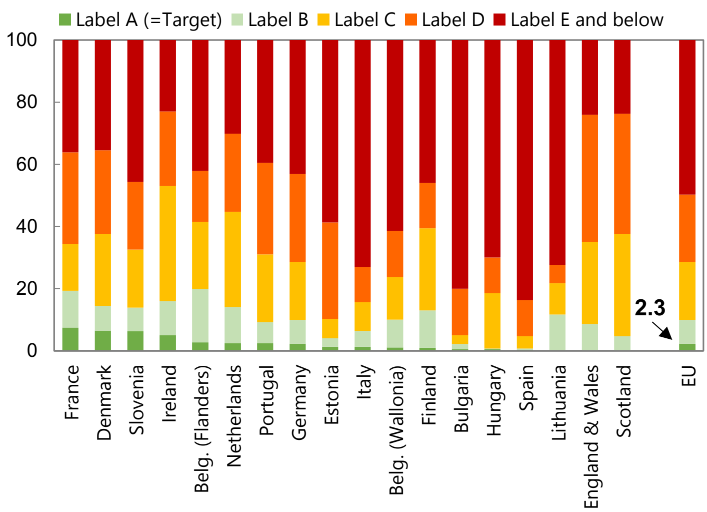
3 In the US, the Biden administration has proposed a Clean Electricity Standard (CES), implemented at the state level which, operationally, works like a tradable CO2 per kWh standard. A federal-level feebate could still be implemented in conjunction with a CES and would provide ongoing incentives to reduce emissions beyond state-level targets, would promote cost-effectiveness in reductions across states, and would be a back-up in the event of legal or other challenges to the CES. The feebate would not require new capacity for monitoring smokestack emissions beyond what is needed for implementing the CES.

The feebate would apply to emissions from fuel combustion and process emissions (e.g. release of CO_2 during the transformation of clinker into cement) and avoids a first-order burden on the average producer as they pay no charge on their remaining emissions. This helps to alleviate concerns about competitiveness and emissions leakage compared with a pricing scheme that charges firms for all remaining emissions. The scheme could build off existing procedures for monitoring firms' emissions under ETSs. A separate scheme would be needed for each distinct industry (corresponding to the different definitions of emission rate per tonne of steel, cement, and so on) but the emissions prices across the different schemes could be harmonised to promote cost effectiveness for the whole industrial sector.

BUILDINGS

In countries (e.g. the EU) with energy performance ratings for buildings, only a small fraction of the building stock currently has a high rating (Figure 3). Energy efficiency renovations – for example, through better insulation and cleaner heating systems – therefore have the potential to dramatically cut energy consumption rates and CO_2 emissions from the building sector. Renovation rates may, however, be hindered by possible market failures, which would warrant some policy intervention even when emissions are aggressively priced (Arregui et al. 2020). For example, landlords may lack incentives to make energy-saving investments if the savings accrue to their tenants and they are unable to charge a rent premium for more energy efficient housing, while renters themselves may lack investment incentives, especially when their tenancy is short-term.

FIGURE 3 DISTRIBUTION OF BUILDING STOCK BY ENERGY PERFORMANCE CERTIFICATE CLASS IN EUROPE



Note: Figure shows portion of the building stock according to five different Energy Performance Certificate classifications, with label A the highest rating.

Source: Arregui et al. (2020).

Feebate schemes could be used to promote adoption of energy efficient appliances by levying fees on product sales in proportion to the difference between energy consumption rates and a market-wide energy consumption rate. Schemes could also apply taxes to gas- and oil-based heating systems and a subsidy for electric heat pumps. And feebate systems linked to energy performance ratings could also be integrated into real estate taxes to encourage energy saving renovations.

FORESTRY

A national forestry feebate programme could cost-effectively promote all responses for increasing carbon storage including afforestation, reducing deforestation, and enhanced management of tree farms (e.g. planting larger trees, longer rotations, fertilizing, tree thinning). The policy would apply fees to landowners at the agricultural/forestry boundary who reduce stored carbon relative to stored carbon on their land in a baseline level and provide rebates to landowners that increase stored carbon. Feebates can be designed, through appropriate scaling of the baseline over time to be revenue-neutral in expected terms. Feebates should involve rental payments – on an annualised basis, a CO_2 price times the interest rate – rather than large one-off payments for tree planting, given carbon storage may not be permanent (for example, due to subsequent harvesting or loss through fires, pests or windstorms). Fees and rebates could be administered based on the registry of landowners used for business tax collection and, while still rudimentary, forest carbon inventories can be inferred from a combination of satellite monitoring, aerial photography, and on-the-ground tree sampling.[4]

AGRICULTURE

Direct monitoring of farm-level emissions from livestock and crop operations is not currently practical. Emissions can, however, be estimated indirectly by combining data on livestock herds, feed, crop production, fertilizer use, and acreage devoted to different practices with default emissions factors. Emissions fees would promote, at the farm level, shifting from livestock to poultry and plant-based production. However, due to potential import competition, these fees might be largely passed back to farmers in lower profits rather than passed forward in higher consumer prices, implying little reinforcement at the consumer level through changes in household diets. Furthermore if, due to reduced competitiveness, reductions in domestic farm production are largely replaced by additional imports, much of the emissions reductions may be offset through leakage.

Feebates related to CO_2 equivalent emissions per dollar of value added, reinforced by fiscal incentives at the consumer level, may be a more effective approach. Under a feebate, farmers would be subject to an annual fee given by the product of:

4 See Mendelsohn et al. (2012) and Parry (2020) for further discussion of design issues for feebates in the forestry sector.

1. a CO_2 price;
2. the difference between their CO_2 equivalent emissions per dollar of output and the industrywide average CO_2 emissions per dollar; and
3. their value of output.

This scheme would cost-effectively promote all behavioural responses for reducing emissions intensity but with no first-order tax burden on the average farmer. From an administrative perspective, the fees and rebates might be integrated into collection procedures for business tax regimes for farmers, using data on proxy emission rates compiled by agricultural ministries.

INTERNATIONAL MARITIME

The International Maritime Organization has pledged to reduce CO_2 emissions from international maritime transport (currently 2% of global CO_2 emissions) by 50% below 2008 levels by 2050. Achieving this target will require development and deployment of zero emission vessels (ZEVs). A carbon levy with price needed to promote deployment of ZEVs as the shipping fleet gradually turns over – in the ballpark of $75 per tonne – would raise considerably more revenue (tens of billions of dollars a year) than needed for research and investment to develop ZEVs and its high tax burden may face opposition at the IMO (Parry et al. 2021). An alternative is to use a feebate variant imposing a much smaller burden on the industry. In this case, ship operators would be taxed on the difference between their CO2 emissions per tonne-mile of freight and a pivot point CO2 emission rate per tonne-mile, multiplied by their total tonne-miles. For a given feebate price, the pivot point can be chosen to meet a revenue target, though separate feebates may be needed for bulk and container shipping.

CONCLUSION

Governments need a range of instruments to implement an effective and acceptable mitigation strategy. Although carbon pricing should play a central role, sectoral measures also have an important reinforcing role. Traditionally, sectoral measures have generally taken the form of emission rate or energy efficiency regulations and subsidies for clean technologies subsidies. Serious consideration should also be given to feebates, however, as they are potentially the most effective and cost-effective instruments for complementing carbon pricing, and they could be potentially applied across all the major emissions producing sectors.

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CHAPTER 21

Making carbon taxation a global win-win

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INTRODUCTION

On 23 September 2019, Greta Thunberg, aged 16, gave an impassioned speech to the United Nations in which she indicted older generations:

> *"You are failing us. But the young people are starting to understand your betrayal. The eyes of all future generations are upon you. And if you choose to fail us, I say: We will never forgive you."*[2]

Greta was appealing to morality. Unfortunately, when it comes to carbon emissions, morality plays second fiddle to self-interest. Imagine, though, that Thunberg had followed up her rebuke with the following:

> *"You have already placed the planet and its young and future inhabitants at grave risk. So let me suggest a deal – a deal you cannot refuse because it comports with your selfishness. The deal is simple. Levy a carbon tax, but cut other taxes that (a) leave you, on balance, better off and (b) leave my generation and future generations to service the larger debt you pass on. Moreover, if you live in a carbon-dependent or cold country, no problem. We can set the path of carbon taxation and region- and generation-specific side payments to achieve the highest uniform welfare gain for you and the rest of humanity, present and future, regardless of where you live."*

Had Greta suggested such a deal, even carbon deniers might have come on board. Greta's hypothetical deal may seem fanciful. It is not. Instead, it reflects the standard economic analysis of externalities and their resolution. Externalities reflect missing markets. With anthropogenic climate change, the mission market is clear. Future generations are not able to purchase carbon mitigation from current generations. However, global fiscal policy can emulate the outcome of missing markets by forcing, via carbon taxation, emitters to

1 We thank the Gaidar Institute, Boston University, the University of Lausanne, the University of Zurich, the Russian Presidential Academy of National Economy and Public Administration and the Swiss National Science Foundation (SNF), under project ID "Can Economic Policy Mitigate Climate-Change?"for research support. We also thank the editors for very helpful comments.
2 Full transcript available at www.npr.org/2019/09/23/763452863/transcript-greta-thunbergs-speech-at-the-u-n-climate-action-summit?t=1631604695124.

pay to emit and then using cross-country and cross-generational net transfers to ensure all parties – current, and future, domestic and foreign – benefit. Indeed, policy can potentially achieve a uniform welfare improving (UWI) gain, measured as a consumption equivalent, for all of today's and tomorrow's planetary inhabitants.

The computational method for achieving uniform Pareto gains was developed four decades ago by Auerbach et al. (1983) and extended by Auerbach and Kotlikoff (1987). This work focused on achieving a more efficient tax system. Nevertheless, as Bovenberg and Heijdra (2002, 1998), Heijdra et al. (2006) and Karp and Rezai (2014) made clear, resolving the climate externality problem entails efficiency gains – gains that can be distributed in countless ways, including uniformly across all agents current and future, domestic and foreign.

Unfortunately, Nordhaus' (1994) seminal book on climate change and most subsequent work on optimal carbon taxation (e.g. Golosov et al. 2014, Cai et al. 2018) frame optimal carbon taxation as either a social planner or a single-agent problem. These are essentially identical mathematical constructs. Their optima are heavily influenced by the weight placed on the future relative to current generations. The social planner framework, taken literally, assumes that a benevolent dictator has the power to impose carbon taxation or achieve the equivalent via command and control. The single-agent model assumes that intergenerationally altruistic dynasties inhabit the planet but fail to coordinate their mutual concern for future generations. Optimal carbon policy puts them on the same page, achieving what devolves into the equivalent of a social planner optimum.

In this chapter, we object to these formulations. They strike us as quasi-religious exercises that have instigated conflict, not cooperation, across generations and regions. After laying out our concerns, we briefly summarise our three recent papers, which treat climate change for what it is – the outcome of selfish generations acting in their own interest. There is no reason to believe that self-interested parties will change their stripes. Consequently, the *sine qua non* for global adoption of a carbon tax is having winners compensate losers. It may also require providing everyone everywhere with the same, or close to the same, stake in ending climate change. We show that in the context of a single-region model, climate taxation is a no-brainer in that intergenerational transfers can make all generations uniformly better off and that such a tax should, therefore, garner uniform support. We also show that in a multi-region model, while side payments are more complicated to calculate, a uniform welfare gain is equally feasible. However, the optics may present a challenge. Low-income regions, such as India, which stand to benefit most from carbon taxation need to pay disproportionately more to compensate regions that do not face major climate damage such as Canada and Russia, which would likely benefit from a higher global, and thus local, temperature. Whether it is possible to persuade a country like India that making large payments to other regions is in its strong interest – because the no carbon-tax alternative will leave it worse off – remains an open question.

THE SOCIAL PLANNER FRAMEWORK

Invoking a social planner may seem a benign practice when it comes to determining optimal carbon policy. After all, doing so ensures that all generations are represented – i.e. their welfare levels are all included. In other words, they are 'weighted'. However, economists are free to conjure planners with very different weights, and indeed have done so (e.g. Stern 2006, Nordhaus 2007). Furthermore, different weights, for which the time preference rate is shorthand, can entail entirely different carbon policies. Social planners that place more weight on the future relative to current generations will adopt higher carbon taxes, and vice versa.

However, even were all economists to agree on their preferred social planner, that planner would optimise her preferences independent of the harm caused to individual agents. Indeed, a social planner would enact a carbon policy even absent a carbon problem if it maximised her welfare. Stated differently, there is no guarantee that the social planner solution will achieve a Pareto improvement. Kotlikoff et al. (2021a) provides an example where moving to a social-planner 'optimum' entails harming some generations to help others.

THE SINGLE-AGENT FRAMEWORK

The single-agent framework assumes that agents are infinitely lived not because they have found the fountain of youth, but because they care about their children's welfare. However, their children care about their children, who care about their children, and so on. This intergenerational altruism leaves each agent caring about all their future progeny and acting as if they will live forever. Intergenerational altruism was originally posited and rejected as nonsensical by Ricardo (1820) because it implies that parents will transfer resources to their children to fully offset implicit and explicit government intergenerational redistribution. However, Ricardo's 'Gedanken experiment' was resurrected by Barro (1974), who elegantly formalised Ricardo's intuition in several simple equations.

Since constructing and solving single-agent models is far easier than solving models with large numbers of concomitant, self-centred life-cycle agents, the 'Barro model' became the go- to tool for macroeconomists as well as those studying climate change. There are, unfortunately, significant problems with invoking this framework. The first is that intergenerationally altruistic agents would, as suggested, find it in their collective self-interest to elect leaders to optimally tax carbon or implement equivalent mitigation policies. The fact that so little has been done for so long in this regard undermines the generational altruism assumption. Second, the model has a little known or, at least rarely acknowledged, absurd implication. Intermarriage across dynasties (single-agent households) links those dynasties altruistically. Consequently, even a very small rate of intermarriage can link the planet altruistically. Such global linkages imply that compulsory redistribution from any agent anywhere to any other agent anywhere will be fully offset via private transfers from the recipient to the donor. This proposition was studied in detail by Bernheim and Bagwell (1988), who expanded on Kotlikoff (1983). Kotlikoff et al. (1988) showed that the Barro model's problem lay in its assumption that recipients could not refuse transfers by donors. Drop that assumption and the problem of dynasties interlinking goes away; but so does the underlying single agent, infinitely lived framework.[3] The third problem is the substantial evidence against intergenerational altruism, at least in the US.[4] Although the social planner and single-agent approaches are analytically tractable and computationally convenient, both seem ill-suited to studying climate change.

PARETO-EFFICIENT CARBON TAXATION

This section summarises three of our recent papers that use large-scale life-cycle simulation models to derive Pareto-efficient carbon policies. First, in Kotlikoff et al. (2021a) we model the world as a single region in a manner analogous to the DICE model (Nordhaus 2015). The model features 55 overlapping generations. Output is produced via energy, both dirty and clean. Absent policy (business as usual, or BAU), climate change reduces output over time, reaching a 30% loss in 2200, given our specification of the damage function. Such damages are more than four times those predicted by DICE. However, since this model does not feature uncertainty, including the potential for tipping points, considering a much more severe damage baseline than in DICE seems the appropriate certainty-equivalent approach.

Dirty energy – be it coal, oil, or gas – is extracted subject to increasing costs. Clean energy is produced with capital, labour, and a fixed factor denoted land. This fixed factor reflects natural limits on green energy production. Nevertheless, it also ensures some clean energy production at all points in time. Technical change in clean energy advances more rapidly than in the production of the consumption/investment good. Consequently, absent policy, clean energy eventually puts dirty energy out of business. This happens in roughly 130 years. However, with the optimal UWI carbon tax, the use of coal ends immediately. As for oil and gas, their remaining years number 80.

The optimal UWI carbon policy involves two components. The first is a tax that starts at $70 and rises, in real terms, at 1.5% annually, with all tax revenues lump-sum rebated to dirty energy producers. The second is generation-specific lump-sum net transfers, which range as high as 10% of lifetime consumption for certain early generations and as high as negative 50% (i.e. a 50% tax) for future generations. The lump-sum net transfers are measured as a share of lifetime consumption or, in the case of current generations, remaining lifetime consumption. It may seem strange that confronting future generations

3 Instead, recipients and donors will engage in a cooperative game that does not admit debt-neutrality.
4 The evidence includes Abel and Kotlikoff (1994), Altonji et al. (1992, 1997), Gokhale et al. (1996) and Hayashi et al. (1996).

with potentially massive taxes could leave them better off. However, that is precisely the case due to the major benefits of carbon mitigation. Our optimal UWI carbon policy raises welfare, measured as a consumption equivalent, by almost 5% for all agents regardless of when they are born.

Our recent work (Kotlikoff et al. 2021c) significantly extends Kotlikoff et al. (2021a). First, we decompose the latter model's single region into 18 regions and include, as part of optimal UWI policy, redistribution across regions as well as across generations within a given region. Second, dirty energy is treated as a CES aggregate of coal, oil, and gas inputs. Third, there is free international trade in output, capital, and dirty energy. Fourth, clean energy is non-traded. Fifth, each region stops using dirty energy of any kind at different dates. Sixth, we compute the regional temperatures from the global temperature by adopting a popular technique from climate sciences called 'pattern scaling' (e.g. Kravitz et al. 2017, Lynch et al. 2017, Tebaldi and Arblaster 2014 and references therein).[5] Seventh, we use a novel damage function, which emulates Krusell and Smith, Jr's (2018) function, that permits negative damages in cold regions. Eighth, we consider the feedback loop in which global average temperature impacts grid temperature and thereby regional temperature, which impacts regional output, which impacts global emissions, which impacts global temperature. Ninth, acknowledging the fact that the DICE-2016 model (Nordhaus 2018) is severely miscalibrated (see Dietz et al. 2021 and references therein), we recalibrate the DICE-2016 climate block relating carbon emissions to atmospheric carbon concentration based on the latest findings from the climate sciences (Folini et al. 2021).

Like our single-region model, our regional model produces region-specific climatic disasters absent policy intervention. With no policy, peak damages in worst-hit regions, such as India, reach very high shares of GDP. Optimal UWI policy shortens dirty energy usage and associated damages dramatically. Unfortunately, even optimal UWI policy leaves the planet facing significant carbon damage. The reason is that we have emitted too much carbon already.

Interestingly, the regional model produces similar optimal UWI carbon taxation and UWI gains. Future generations in regions facing the greatest damages face the highest net taxes in the UWI solution. This, too, may seem strange. Why tax the worst-hit generations in the worst-hit regions the most? The answer is simple: such generations benefit the most from carbon mitigation. Moreover, thanks to the benefits derived from reduced emissions, such generations end up, on balance, better off to the same degree as everyone else regardless of their place of time of birth. Our third study (Kotlikoff et al. 2021b) considers Pareto-improving carbon-risk taxation.

5 Pattern scaling was first introduced by Santer et al. (1990). It is a statistical method that, based on large- scale Earth system models, relates, for instance, the global average temperature in a computationally efficient fashion to local temperatures at resolutions as fine as about 1° longitude x 1° latitude.

Carbon-risk taxation references taxing carbon not to reduce its likely/average future impact but to limit the chances that climate damages are far larger than projected. To isolate the climate risk problem, we consider three mean-zero, symmetric shocks in a 12-period, overlapping generations model. These shocks impact dirty energy usage, the relationship between carbon concentration and temperature, and the connection between temperature and damages. Welfare is measured as each unborn generation's ex-ante (e.g. 120 years before being born) expected entire lifetime utility or, for current generations, expected remaining lifetime utility. By construction, our model exhibits a de minimis climate problem absent its shocks. However, due to non-linearities and risk aversion, symmetric shocks deliver negatively skewed impacts, including the potential for colossal climate disasters with attendant terrible welfare losses.

As we show, Pareto-improving carbon taxation can dramatically lower climate risk in general, and disaster risk in particular. The associated climate risk tax, which is focused exclusively on limiting climate risk, can actually exceed the carbon average-damage tax, which is focused exclusively on limiting average damage.

CONCLUSION

High carbon taxes that lead to an almost immediate shutdown of coal production coupled with appropriate intergenerational redistribution through fiscal policy are a no-brainer. The potential to meaningfully share gains from carbon taxation is clear. Doing so will leave everyone, no matter their place or year of birth, with a material incentive to support carbon taxation – there lies the path forward.

The political economy of such taxes in a multi-region world with large differences in incomes and reliance on fossil fuels is subject to further research. Also subject to further research is the question of whether one can deduce UWI carbon policies in large-scale life-cycle models with positive average damages and significant downside risk. From a theoretical perspective, if future downside shocks are sufficiently large and sufficiently far off, those exposed to these shocks may not be able to sufficiently compensate current generations to achieve a uniform proportional increase in ex-ante expected utility.

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CHAPTER 22

Why do we need a Carbon Border Adjustment Mechanism? Towards the development of a Climate Club

Luis Garicano and María Fayos
European Parliament, IE Business School (On Leave) and CEPR; Harvard University

INTRODUCTION

Fighting climate change is a global public good. Like other public goods, it has two key properties: it is non-excludable (all benefit from the efforts of any one individual) and non-rival (my consumption does not decrease yours). However, unlike other public goods, its (non-excludable) benefits encompass the entire globe: all humanity benefits from the climate fighting effort of any one individual.

As a result, it is subject to the worst form of free riding. When a country makes an effort to reduce its carbon footprint, all other countries benefit from its efforts, while it alone incurs the costs of such efforts. Countries may rely on others to fight climate change while proceeding with their own development and growth efforts unencumbered by any climate concern.

Public goods problems are often solved by the presence of a government. Since defence is a public good, governments tax their citizens and provide defence for all of them. However, there is no global government able to force the international community to cooperate on the provision of global public goods, such as fighting climate change. Solving this collective action problem is probably the most important issue facing humanity right now.

Pricing carbon is probably the most cost-effective way to fight climate change. However, to work efficiently and avoid competition distortions, emissions must be priced everywhere. Unfortunately, international efforts have had limited success in this front. In spite of 30 years multilateral efforts on climate change, more than 70% of global CO_2 emissions are still not subject to any pricing mechanism or tax (OECD 2020), resulting in an unsustainable equilibrium: global greenhouse gas emissions have increased by more than 40% since 1990.[1] These figures highlight the failure of multilateral attempts to overcome climate change, hampered by their non-binding nature and without mechanisms to avoid free riding.

1 www.climatewatchdata.org/ghg-emissions?end_year=2018&start_year=1990

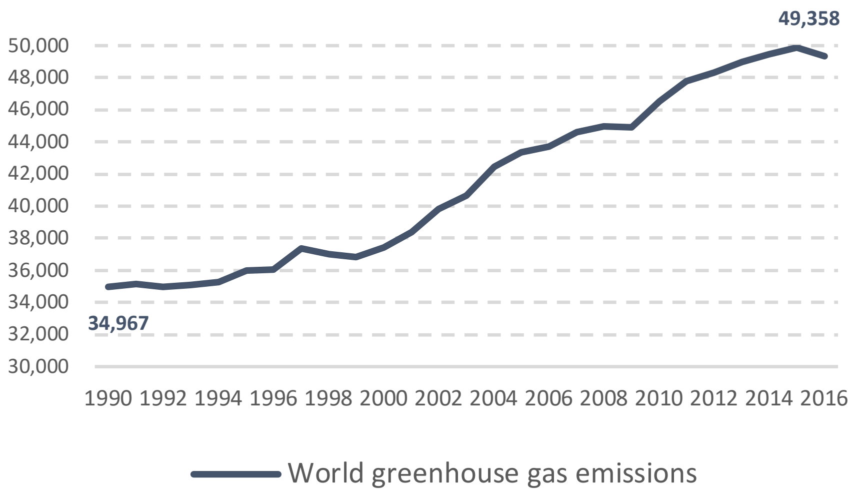
In this context, several regions of the world have introduced unilateral climate objectives. The European Union is a good example. In 2005, EU member states introduced the first major carbon market: the EU Emissions Trading Scheme (EU ETS). It is a 'cap-and-trade' system limiting emissions from more than 11,000 heavy energy-using installations and airlines (representing around 40% of the EU's greenhouse gas emissions). Emitters under the EU ETS have to buy carbon allowances at market price to cover their level of emissions.

However, in the absence of a global price on carbon emissions or carbon border mechanisms, unilateral efforts are doomed to accelerate 'carbon leakage' dynamics – i.e. moving production outside of regions with carbon pricing schemes towards countries with laxer climate policies (that find themselves at a competitive advantage). As a result, domestic production is replaced by cheaper and more polluting imported goods, while world carbon emissions increase.

This 'offshoring of emissions' trend is already alive and well. The case of the EU illustrates this well. While the EU has managed to reduce its carbon emissions substantially (by 21% between 1990 and 2018), this reduction has been offset by the increase in net imports of carbon from third countries (by 28% in the same period).

FIGURE 1 WORLD GREENHOUSE GAS EMISSIONS HAVE INCREASED BY 40% SINCE 1990

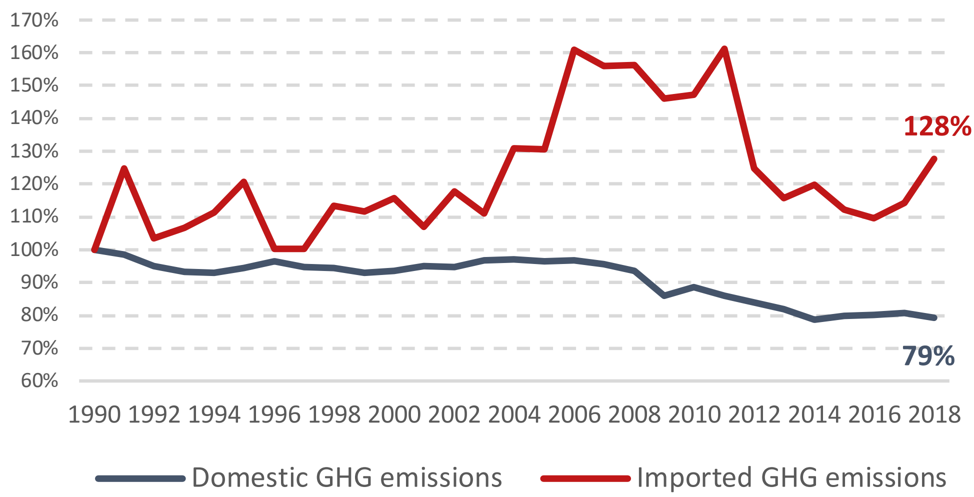
Mt of CO_2 equivalent



Source: World Resources Institute.

FIGURE 2 REDUCTION OF EU GREENHOUSE GAS EMISSIONS HAS BEEN OFFSET BY INCREASED CARBON IMPORTS

Base 100 in 1990



Source: Our World in Data

To overcome the failure of unilateral and global (voluntary) efforts to control carbon emissions, the EU has just proposed a concrete design for the implementation of a Carbon Border Adjustment Mechanism (CBAM). The proposal is based in a simple premise: make importers pay for the carbon content embedded in their products in the same manner as EU-produced goods do under the EU ETS, the world largest cap-and-trade carbon market.

The CBAM fills an essential gap in the EU climate policy as it would eliminate the carbon-pricing advantage of producing abroad and selling domestically because the carbon price would be the same regardless of where production takes place (Kortum and Weisbach 2017). This is key if the EU wants to meet its long-term objective of climate neutrality by 2050. To meet this objective, the EU will need to make significant decarbonisation efforts. As a result, the carbon price paid by domestic producers under the EU ETS is expected to significantly increase, likely well beyond the current price. In the absence of a global price on carbon emissions, this means that the risk of carbon leakage will intensify. By ensuring that the price of imports reflects their carbon content, the CBAM will assure that the EU's green objectives are not undermined by the relocation of production or by increased imports from countries with less ambitious climate policies. In parallel, the CBAM can also represent an incentive for trade partners to decarbonize. Overall helping decrease global emissions (Drake 2018).

FIGURE 3 INCREASING CARBON PRICE UNDER THE EU ETS

Primary market auction price, €/tCO2

Source: EEX, EU primary auction spot data (as of May 20201).

Finally, the CBAM can be considered as the entry ticket to a 'Climate Club' (Nordhaus 2015). Members of the club incur the costs of climate abatement through carbon pricing schemes, while non-members (i.e. countries with no carbon prices) contribute to the global effort through the 'fees' they must pay to export to the club. Ideally, the number of members of the club becomes sufficiently large, and the fees sufficiently high, that all countries have an incentive to join the club (i.e. to start pricing their carbon emissions). Consequently, the CBAM could be a first step into the establishment of a new global order for international climate policy (Rodrik and Walt 2021).

To succeed, the CBAM should clearly and exclusively be designed to support climate objectives and not be misused as a tool to enhance protectionism. It should also comply with WTO rules.

We believe that the design proposed here (see Garicano 2021 for details) reflects such an environmental objective. First, the CBAM is expected to mirror the price being charged to EU producers, and cover the same sectors, in order to ensure fairness and non-discrimination between domestic producers and foreign importers (nor among them). Second, it would avoid importers paying twice for the carbon content embedded in their products, taking into consideration existing carbon pricing measures in third countries. Consequently, the measure would incentivise trade partners to enhance their climate efforts through the introduction of carbon pricing schemes. Third, it would also allow importers to demonstrate their real carbon emissions level to incentivise decarbonisation investments at production plant level.

The details of the proposed design parameters of the CBAM are as follows:

1. POLICY INSTRUMENT: EXTENSION OF THE EU ETS

Among the different options considered for the implementation of the CBAM – a customs duty, a tax on consumption, or the extension of the ETS – the latter seems to hold the larger number of advantages. A system based on the existing ETS will facilitate WTO-compatibility as a 'mirror' system of the carbon market faced by domestic producers, hence avoiding discrimination between domestic producers and foreign importers. It will ensure automatic price adjustment at the same level as domestic producers. It will also avoid adding an additional burden on EU producers, who already face decarbonisation policies through the ETS. Finally, it might count with bigger public and political support (which has been lacking for previous carbon taxes) and be less perceived as a protectionist measure by EU's trade partners.

2. SECTORAL SCOPE: ANY IMPORT EMBEDDING BASIC MATERIALS COVERED BY THE EU ETS

As a mirror system of the ETS, it is essential that the CBAM keeps the same sectoral coverage in order to prevent potential distortions and substitutions effects. If the CBAM is not introduced with such a broad sectoral scope, it might cause irreversible damage to some industries.

- In the absence of 'horizontal coverage', distortions between substitute products could erase. As sectors not covered by the CBAM would automatically become more competitive than those covered by the CBAM (e.g. cement versus aluminium versus glass in the construction sector). Those distortions would exacerbate if the CBAM were also to trigger the phase-out of free allowances only for a subset of sectors.
- In the absence of 'vertical coverage', ie. if only raw materials are targeted by the CBAM, but not intermediate or end-products, the risk of carbon leakage could actually intensify. As we would be creating a loophole in the system: imports in the form of intermediate or end products would not be subject to the CBAM, nor the ETS.

Despite the call for a broad sectoral coverage, the European Parliament acknowledges the technical difficulties of covering as early as 2023 all basic materials under the EU ETS and understands that sectors deemed at highest risk of carbon leakage may be prioritised. In this case, the Commission should include a binding calendar for broadening the coverage of the CBAM, with the objective of giving a clear and predictable timeline for industrial stakeholders.

3. EMISSIONS SCOPE: DIRECT AND INDIRECT EMISSIONS ARISING FROM ELECTRICITY CONSUMPTION

Our proposal calls for the CBAM to cover direct emissions (scope 1) and indirect emissions arising from electricity consumption (scope 2), in order to fully internalise products' carbon footprint. The inclusion of scope 2 emissions, even if it may complexify the mechanism, seems essential as decarbonisation investments (such as the introduction of carbon capture and storage systems) are expected to reduce scope 1 emissions at the expenses of increasing scope 2 emissions.

4. CALCULATING THE EMBEDDED CARBON CONTENT USING THE WEIGHT OF BASIC MATERIALS

Assessing the real carbon content of each import is unfeasible. An administratively feasible trade-off needs to be considered. In that regard, the utilisation of the weight of basic materials embedded in each product, and the utilisation of default carbon intensity values (ie. benchmarks) provides a good approximation to the true carbon content of any given product, as the bulk of emissions of any industrial item are embedded in the basic materials.

The question, then, is which emissions benchmark should be considered? The best compromise would be to have a 'world average' assessing the average carbon intensity value for any given product. While world average default values would probably benefit high-polluting countries (compared to country-specific values), they will still reflect a higher carbon content than default values based on EU products, therefore representing a better approximation of imports' carbon content. Indeed, the EU average carbon intensity values should not be used, as an overly low carbon intensity default value would be disappointing from an environmental standpoint: it would reduce the incentive effect for importers to outperform the default value and would encourage them to settle for the default payment – hence not fulfilling the environmental objective of the CBAM.

In addition, the mechanism should allow importers to substitute the actual default value if they can demonstrate that their specific production process is more carbon efficient. This is essential to incentivise greener production and to ensure non-discrimination.

FIGURE 4 ASSESSMENT OF CARBON CONTENT: IMPORTED CAR EXAMPLE

1. Determining the tax base: basic materials under the ETS embedded in the product				
Basic Materials	Mass	Direct emissions GHG intensity	Indirect emissions GHG intensity	GHG content
Unit	***tonnes***	***t CO2 equivalent / t of product***	***t CO2 equivalent / t of product***	***tonnes CO2 equivalent***
Steel	2,50	1,75	1,12	7,18
Glass	0,15	0,91	1,23	0,32
Aluminum	0,80	1,44	2,37	3,05
Polyethylene	0,25	0,88	0,42	0,33
Total	**3,70**			**10,87**
2. "Taking" the tax price				
EU ETS market price		*in € / tonne CO2 equivalent*		35
3. Total CBAM price for the car				
Total CO2 equivalent emissions		***tonnes***		**10,87**
Direct emissions (scope 1)		*tonnes*		5,88
Indirect emissions (scope 2)		*tonnes*		4,99
Price per tonne		***€ / tonne CO2 equivalent***		**35**
Total price		**€**		**380,42**

Note: Dummy data, just for example purposes.

Source: Author.

5. ARTICULATION WITH THE EU ETS

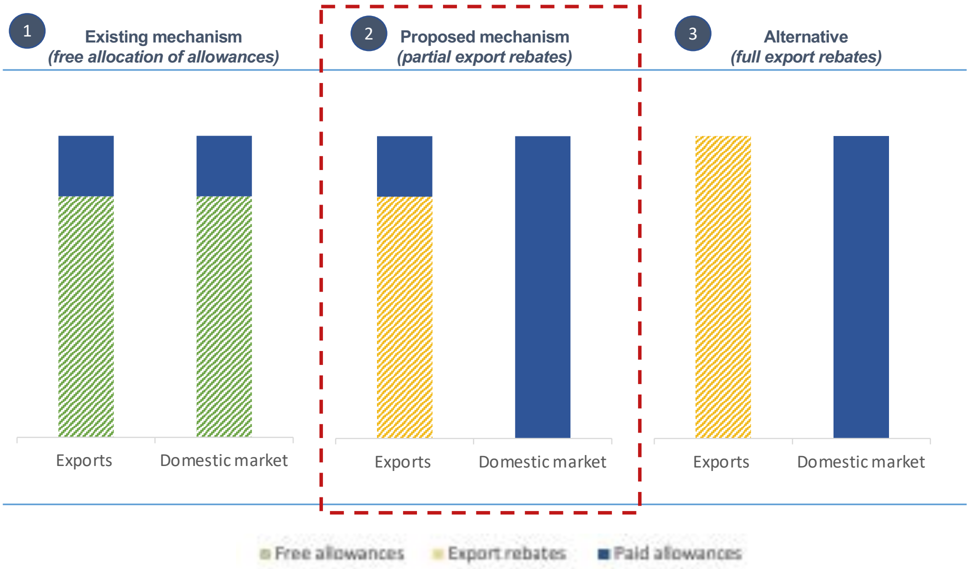
The CBAM offers, from an environmental and fiscal perspective, the opportunity to trigger the phase-out of existing measures to prevent carbon leakage, such as free allocation of allowances and financial compensation for indirect emissions (European Commission 2015) – those measures are considered not suitable as they reduce the overall cost of emissions.

The CBAM would ensure that local producers subject to the ETS would be no longer at a competitive disadvantage in the domestic market compared to importers from jurisdictions with laxer environmental standards.

In parallel, to ensure that export-oriented sectors are also protected from the risk of carbon leakage, it is proposed to couple the CBAM with partial export rebates. Those partial export rebates would be based on the existing benchmark logic of most carbon-efficient producers, not refunding more than the current level of free allocation of allowances. As a result, such partial export rebates would maintain strong decarbonisation incentives, increasing WTO-compatibility while ensuring a level playing field for EU exports.

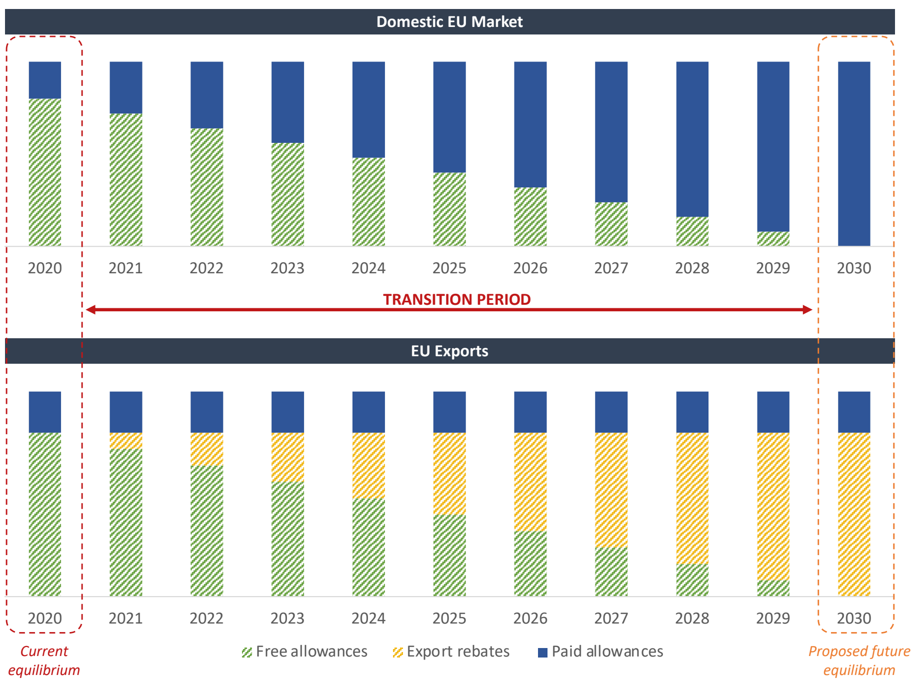
The proposed partial export rebate has significant advantages compared to both: the status quo (i.e. keeping free allocations) or the introduction of full export rebates (Garicano 2021). The status quo is not satisfactory as the free allocation of allowances leads to an equilibrium with lower decarbonisation incentives both for EU producers and foreign importers. On the other hand, the introduction of full export rebates will remove decarbonisation incentives for export-oriented producers in the EU and would more likely not be considered WTO-compatible as it would weaken the climate ambition of the measure.

FIGURE 5 COMPARISON BETWEEN SEVERAL EXPORT REBATES SETTINGS



Source: Author.

FIGURE 6 TRANSITION PERIOD: THE PHASE-OUT OF FREE ALLOCATION OF ALLOWANCES SHOULD BE SYMMETRICALLY COUPLED WITH THE INTRODUCTION OF PARTIAL EXPORT REBATES



Source: Author.

The proposal is therefore to symmetrically couple the phasing-out of free allocation of allowances with the introduction of partial export rebates, during a transition period of coexistence of all the measures. This transition period would be essential to provide regulatory certainty to resource- and energy-intensive industries, in order not to face an abrupt removal of free allowances. The transition period would also serve as a trial period for the CBAM.

6. CREDITING FOR FOREIGN POLICIES: CARBON EMISSIONS SHOULD NOT BE PAID TWICE

The implementation of the CBAM should take into consideration the climate policies of third countries in order to fully incentivise trade partners to increase their climate efforts. Importers should be allowed to justify whether the carbon in their products has been already been priced, which would be deduced from their payable amount. It could also be encouraged to introduce specific standards for this purpose, for instance developing equivalence agreements of carbon pricing methodologies in the context of bilateral agreements.

CONCLUSION

We believe that the implementation of the CBAM fills an essential gap in the EU climate policy. In the next years, the risk of carbon leakage might exacerbate. The EU's increased climate ambition, as given by the objective of achieving climate neutrality by 2050, involves making larger efforts to decarbonise the economy. As a result, the carbon price paid by domestic producers under the EU ETS is expected to significantly increase beyond the current price of close to €50 per tonne, further accentuating the 'offshoring of emissions' dynamics. As a result, if the EU wants to achieve climate neutrality by 2050 while keeping its industry on its soil and making a real impact on reducing emissions globally, a CBAM is of the essence.

The CBAM has also the potential to foster a new global order for international climate policy. In that regard, the stakes are high. Engaging with third countries to ensure that the mechanism is not perceived as a protectionist measure will be key to avoid retaliation. Further, the EU needs to polish every technical detail to make sure that the mechanism delivers as planned.

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CENTRE FOR
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We are in the midst of a process of unprecedented climate change, which is already wrecking severe damage to the livelihoods of billions around the globe. Greenhouse gas emissions around the globe should be reduced as fast as possible and reach net zero in the second half of the 21st century. To ensure that the world's climate goals are met, effective policies must be implemented. The golden prescription of economists is to price carbon uniformly across the globe and compensate any losers, but the reality of implementing climate policies is fraught with pragmatic and political obstacles which differ from country to country.

The aim of this eBook is therefore to offer contributions to each of the featured nations' debates over the climate change policies to fast track. Which policies will have the fastest and/or largest cumulative impact? Which ones are the most technically or financially feasible? Which are least likely to hit prohibitive political-economy obstacles to their implementation? Which ones are cheapest in abating emissions?

Despite several common themes addressed in the 18 chapters on individual countries, the separate chapter on the Green Deal for the European Union, and the three chapters dealing with cross-country broader issues such as feebates, border tax adjustments and transfers, the specific answers to the posed questions often differ by country depending on climate policies already in place, political constraints the country's geography, and so on. This implies that one country can learn from the debates taking place in another.

The detailed appraisals found in the chapters of this book aim at inspiring policymakers. The arsenal of policies to achieve net zero emissions is rich and varied, and any delay in implementing these will lead to much higher costs. There is no sound reason to delay climate action.

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