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BUILDING A GREENER RECOVERY:

LESSONS FROM THE GREAT RECESSION

Covid-19 Green Recovery Working Paper Series

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EXECUTIVE SUMMARY

Rebuilding a greener world economy after the COVID-19 pandemic requires learning from what worked and what did not from past efforts to adopt green stimulus during the 2008-9 Great Recession. These investments emphasized energy efficiency spending and "shovel-ready" clean energy projects. They impacted job creation and expansion of renewables for several years but provided little long-term support for de-carbonizing the world economy. The biggest obstacles have been major market disincentives, especially the underpricing of fossil fuels and market failures that inhibit green innovation. However, since the Great Recession, new trends have emerged that must also be considered. These include widening wealth and income inequality, the growth in private wealth while public debt rises, and the lack of progress in achieving key Sustainable Development Goals (SDGs). There are three key lessons:

- Policies for a sustained economic recovery amount to much more than just short-term fiscal stimulus. Green structural transformation will require long-term commitments (5 to 10 years) of public spending and pricing reforms.
- The package of reforms will be different for major economies, such as the Group of 20 (G20), and low and middle-income economies, reflecting their different structural conditions and needs.
- Any package of green and inclusive reforms must be fiscally sustainable. Countries with limited fiscal space and debt constraints must find new room for maneuver. Pricing and market-based incentives are essential, both to foster green investments and innovations and to provide revenues for the increase in public spending.

The global public health and economic crisis created by the pandemic is creating a growing financial burden on all governments. In addition, the lack of international support and coordination for ensuring progress towards the 17 Sustainable Development Goals (SDGs) has made developing countries more vulnerable to the pandemic than they should be. In G20 economies, the priorities for public spending include support for private sector green innovation and infrastructure, development of smart grids, transport systems, charging station networks, and sustainable cities. Pricing carbon and pollution and removing fossil-fuel subsidies, can accelerate the transition, raise revenues for the necessary public investments, and lower the overall cost of the green transition. Developing countries will need to find cost-effective and innovative policy mechanisms to achieve sustainability and development aims in the absence of significant infusions of additional financing from major economies and international organizations. This requires identifying affordable policies that can yield progress towards several SDGs together, rather than sacrificing some goals to achieve others. Three policies meet these criteria: a fossil fuel subsidy swap to fund clean energy investments and dissemination of renewable energy in rural areas; reallocating irrigation subsidies to improve water supply, sanitation and wastewater infrastructure; and a tropical carbon tax, which is a levy on fossil fuels that funds natural climate solutions.

Keywords: carbon pricing; clean energy; COVID-19; G20 economies; green economy; Green New Deal; green recovery; natural climate solutions.

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INTRODUCTION

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BUILDING A GREENER RECOVERY: LESSONS FROM THE GREAT RECESSION

All indications suggest that the global economic recovery from the COVID-19 pandemic will be long and arduous.

Already, the fiscal bill for tackling the health emergency and the economic crisis is large and mounting. Governments worldwide are likely to face a $10 trillion deficit in 2020 and a cumulative shortfall of up to $30 trillion by 2023 (Assi et al. 2020).

The immediate economic priorities should be to relieve the human suffering caused by the disease, protect livelihoods and incomes, and shore up businesses and industries hardest hit by the recession. But managing the long recovery is also critically important. As the OECD (2020, p. 3) has emphasized, "a more resilient economy depends on a shift to sustainable practices". The alternative course of simply reviving the existing "brown" economy will exacerbate irreversible climate change and other environmental risks. Consequently, "building back better" means also addressing "an even bigger future threat to the global economy: environmental degradation driven by our current economic system" (OECD 2020, p. 3).

Devising green strategies for the economic recovery is becoming essential. Although global carbon dioxide (CO2) emissions have fallen sharply during the pandemic, they have risen by 1% annually over the past decade as growth in energy use from fossil fuels outpaced the rise of low-carbon sources and activities (Jackson et al. 2019; Peters et al. 2020). The 2020 fall in global CO2 emissions of around 2-7% over 2019 levels is likely to be temporary, as the world economy recovers (Le Quéré et al. 2020).

There is also concern that the pandemic will further undermine the commitment to global action on climate, biodiversity and other environmental issues (UN 2020). Of the $12 trillion committed by the 50 largest economies to the pandemic recovery so far, only about 10% has gone to sectors and activities that could potentially contribute to a green future (Green Fiscal Policy Network and Oxford Smith School, 2020 (forthcoming)). Evidence is also emerging that the crisis has led to a weakening of environmental regulations and their enforcement worldwide, with consequences for environmental quality, pollution and land use change (Helm 2020; Troëng et al. 2020). It has also slowed innovation and investments in clean energy, thus seriously damaging the prospects for transition to a low-carbon economy (Gillingham et al. 2020)

Given these concerns, the post-pandemic recovery offers a unique opportunity to develop affordable and workable policies to usher in a more sustainable and low-carbon world economy. To assist such a strategy, the following report focuses on:

- what worked and what did not from previous efforts by the G20 to green the economic recovery from the 2008-9 Great Recession, and
- more recent economic conditions and trends that must also be considered in devising a post-coronavirus green recovery.

Several lessons emerge from this review.

First, policies for a sustained economic recovery amount to much more than just short-term fiscal stimulus of 1-2 years. Instead, transitioning from fossil fuels to a low-carbon, greener economy will require long-term commitments (5 to 10 years) of public spending and pricing reforms. As a consequence, the policies chosen for short-term (1-2 years) fiscal measures differ from the policies for a medium to long-term (5-10 years) green economic recovery and transition.

Second, public spending alone cannot create a greener economy. Pricing reforms, such as phasing out fossil fuel subsidies and taxing carbon and environmental damages, are also necessary to provide the incentives for green investments and innovation, reduce fossil fuel dependency and create a more sustainable economy.

Third, the package of public investments and pricing reforms will be different for major economies, such as the Group of 20 (G20), and low and middle-income economies, reflecting their different structural conditions and needs.

Finally, any package of green and inclusive reforms must be fiscally sustainable. Countries with limited fiscal space and debt constraints must find new room for maneuver. Pricing and market-based incentives are essential both to foster green investments and innovations and to provide revenues for the increase in public spending.

The rest of this report reviews efforts to introduce green stimulus and recovery efforts during the Great Recession, as well as key trends since then. It then discusses their implications for constructing a post-pandemic green recovery strategy for both G20 and low and middle-income countries today, and how such a strategy can lead to inclusive green growth.

GREEN STIMULUS AND THE GREAT RECESSION

2

As the economic downturn caused by the COVID-19 pandemic has deepened, attention has shifted from addressing the immediate crisis to how to "build back better" (OECD 2020; UN 2020). There are increasing proposals for developing a "greener" fiscal response, in order to ensure that climate goals are not sacrificed (Agrawala et al. 2020; Hepburn et al. 2020; Kaufman 2020).[1] Many of these proposals suggest that the lessons learned from the green stimulus implemented during the 2008-9 Great Recession should be applied to green the current recovery from the pandemic.

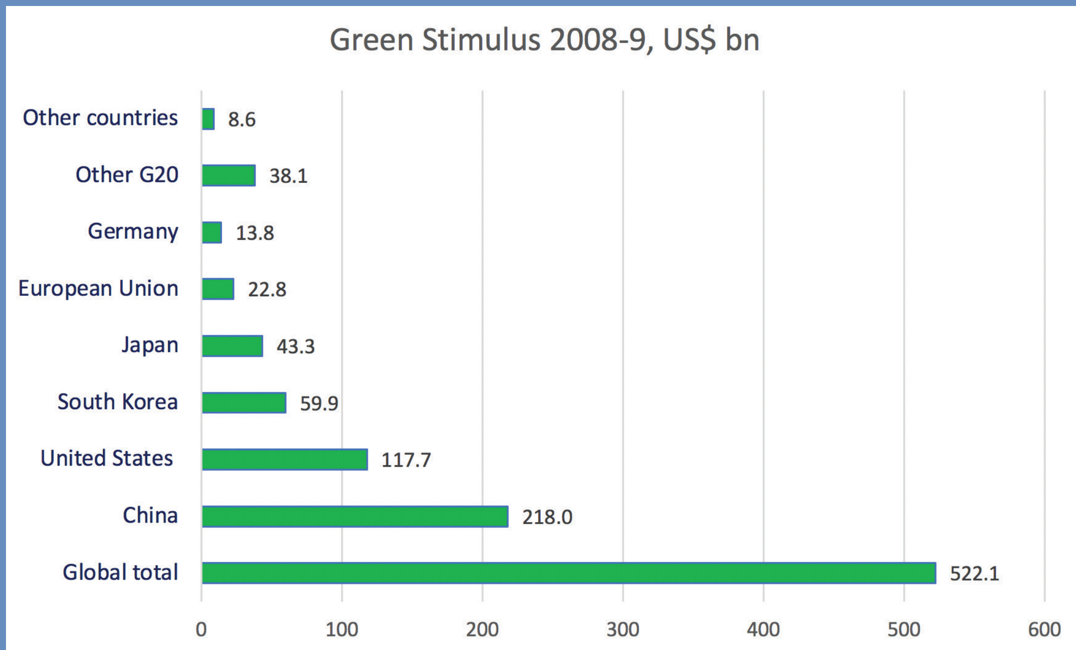
This section further reviews past efforts to stimulate a green recovery from the 2008-9 Great Recession, with the aim of highlighting possible lessons for a post-pandemic recovery. [2]

Of the $3.3 trillion in global fiscal stimulus during the Great Recession, around $522 billion (16%) can be classified as "green investments", such as low-carbon energy, energy efficiency, pollution abatement and materials recycling (Barbier 2010a and 2016a). Almost all of this entire green stimulus was by the G20 economies (see Figure 1). In fact, just four economies – China, the United States, South Korea and Japan - accounted for around 85% of the global green stimulus over 2008-9.

1 An interesting hybrid proposal is three-year investment recovery plan based on fostering clean energy proposed by the IEA (2020), which would cost $1 trillion annually (0.7% of global GDP). The plan endorses many of the specific policies suggested here, including the phasing out of fossil fuel subsidies, but stops short of ending underpricing of fossil fuels through carbon taxes and other market mechanisms.

2 See also Agrawala et al. (2020), who conduct an in-depth review of many national green stimulus packages enacted during the 2008-9 Great Recession. IEA (2020) also reviews lessons from these packages for their sustainable recovery plan for the global energy sector. During the 2008-9 Great Recession, I assisted the United Nations Environment Programme (UNEP) in devising their "Global Green New Deal", a plan to build on green stimulus efforts to construct a sustained green recovery (Barbier 2010a). Since then, I have also periodically reviewed progress in green policies worldwide, including recent Green New Deal proposals (Barbier 2010b, 2016a and 2019), as well as strategies for greening the post-pandemic recovery in G20 and low and middle-income countries (Barbier 2020a; Barbier and Burgess 2020).

FIGURE 1. GREEN STIMULUS IN THE 2008-9 GREAT RECESSION



Green stimulus includes all support for: i) low-carbon power: renewable energy (geothermal, hydro, wind and solar), nuclear power, and carbon capture and sequestration; ii) energy efficiency: energy conservation in buildings, fuel efficient vehicles, public transport and rail, and improving electrical grid transmission; and iii) water, waste and pollution control, including water conservation, treatment and supply.

G20 is the Group of 20 countries. The members of the G20 include 19 countries (Argentina, Australia, Brazil, Canada, China, France, Germany, India, Indonesia, Italy, Japan, Mexico, Russia, Saudi Arabia, South Africa, South Korea, Turkey, the UK and the US), plus the European Union.

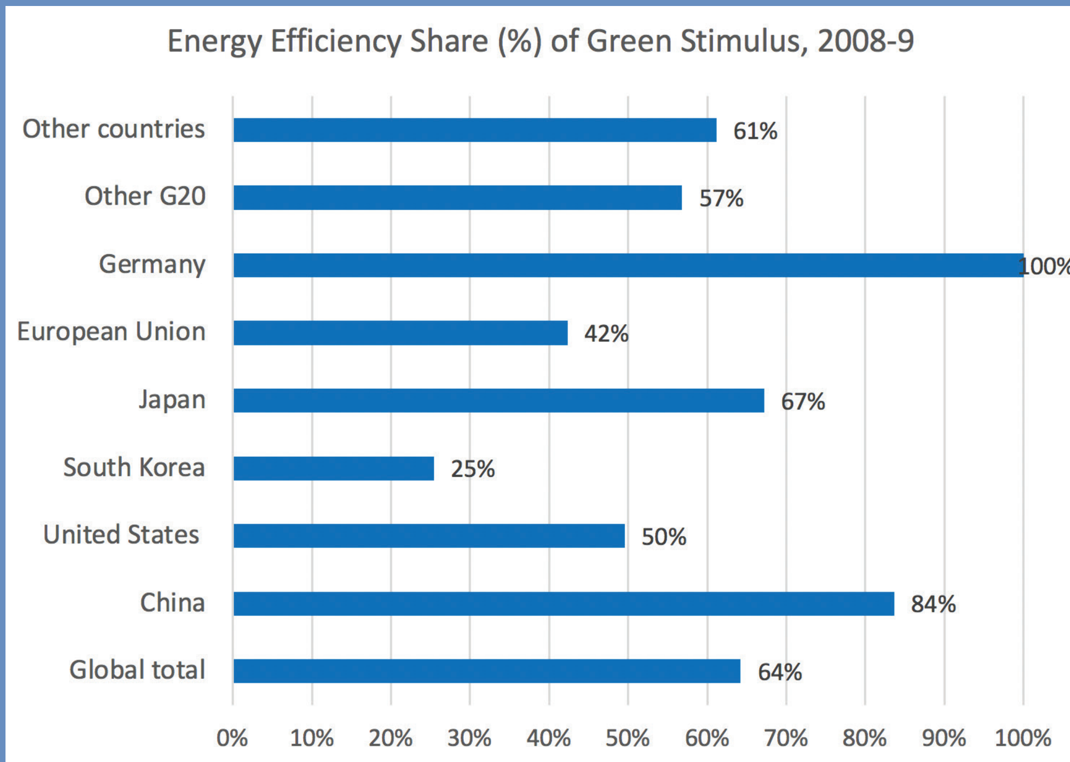
The direct contribution by the European Union is included separately from that of individual EU members.

Source: Barbier (2010a) and (2016a).

Nearly two thirds of the global green stimulus ($335 billion) went to improving energy efficiency, with an aim to create much needed jobs in sectors hard-hit by the Great Recession, such as construction (see Figure 2). Among the four countries that enacted most of the green stimulus during the Great Recession, three allocated sizable shares to energy efficiency – China (84%), United States (50%) and Japan (67%). The European Union directed 42% of its green stimulus to energy efficiency, and Germany all of it[3]. In comparison, only a quarter of South Korea's green stimulus went to energy efficiency. Instead, it promised to spend 5% of GDP ($60 billion) over 2009-2013 as part of a long-term strategy to develop key green industries, such as solar panels, electric cars, wind turbines and high-speed trains, as well as for projects on river restoration and flood control (Barbier 2010a).

3 Similar to Germany, major European economies also allocated much of their green stimulus to energy efficiency. For example, the entire green stimulus of Italy was for energy efficiency, 84% of the UK's green stimulus and 83% of France's (Barbier 2010a and 2016).

FIGURE 2. ENERGY EFFICIENCY AND 2008-9 GREEN STIMULUS



Energy efficiency consists of all support for energy conservation in buildings, fuel efficient vehicles, public transport and rail, and improving electrical grid transmission.

Source: Barbier (2010a) and (2016).

Several important lessons emerge from these national experiences.

First, the green stimulus packages enacted during the Great Recession followed the general recommendation for all fiscal stimulus packages that they be "timely, targeted and temporary" (Aldy 2013). The emphasis on energy efficiency spending, and "shovel-ready" clean energy projects did impact job creation and expansion of renewables for several years but provided little long-term support for de-carbonizing economies that undertook green stimulus during the 2008-9 Great Recession.

For example, in the United States, green stimulus did help growth of renewable energy (Aldy 2013; Carley 2016; CEA 2016a and 2016b; Mundaca and Richter 2015). From 2008 to 2015, the share of non-hydropower renewables in electricity generation increased from 3% to 7% (CEA 2016b). And while this growth reduced CO2 emissions, the more significant impact came from the slow-down in the economy and switching from coal to natural gas due to the availability of relatively cheap natural gas. In addition, most of the increase in new electricity generation from renewables has been mostly due to the large declines in the capital costs of wind and solar installation and generation capacity since 2008 (CEA 2016b; Lazard 2019).

However, there are also signs that any initial progress in de-carbonizing the US economy may have slowed in recent years. Since 2013, CO2 fossil fuel emissions have declined modestly, but as renewable and other sources of low-carbon energy continue to grow, so has growth in energy use from fossil fuels (Jackson et al. 2019; Peters et al. 2020). Overall, it is the displacement of coal by natural gas and reduction in overall US electricity demand that is exerting a greater influence on CO2 emissions than the expansion of solar and wind power for electricity generation or the use of hybrid and electric vehicles (Jackson et al. 2019; Peters et al. 2020). This is largely attributable to the failure in implementing additional incentives, such as pricing carbon, and the "policy void" of any substantial public spending initiatives on the environment since the Great Recession (Barbier 2016a).

A second lesson from the Great Recession is that the composition of green public investments matters. Even for a long-term investment program, as in the case of South Korea's five-year Green New Deal, expenditure on large-scale infrastructure projects for water and construction appear to be less important to sustainable development and de-carbonization than more targeted policies, such as public support for green R&D investment in the economy (Barbier 2020a). While the Korean Green New Deal did succeed initially in spurring growth and employment, its longer term aims of a green economic transition has fallen short (Choi and Qi 2019; Duffield 2014; Ha and Byrne 2019; Sonneschein and Mundaca 2016) In the end, South Korea may have spent only $26 billion on low-carbon energy as part of its Green New Deal and instead spent much more on water control (Sonneschein and Mundaca 2016). It also failed to adopt pricing reforms and other policy incentives to foster growth in renewables, such as phasing out fossil fuel subsidies, enforcing carbon targets and stringent regulatory frameworks. This has slowed the pace of adopting renewables, reducing energy intensity and slowing greenhouse gas emissions (Ha and Byrne 2019).

The final key lesson from the Great Recession is that spending alone will not green an economy over the long term. There is also a need for complementary pricing reforms, such as phasing out fossil fuel subsidies and taxing carbon and environmental damages. For example, in the United States the green stimulus following the Great Recession was meant to be combined with a carbon cap-and-trade program, which would have substantially increased renewable energy investment even after the short-term stimulus had expired (Mundaca and Richter 2015). The failure to adopt such a program or any carbon tax has meant that renewables are unlikely to displace fossil fuels anytime soon as the major source of energy in the US (Barbier 2020a; Metcalf 2019). Similarly, although South Korea did adopt a carbon emissions trading scheme (ETS) in 2015, it has failed to reduce carbon emissions significantly (ADB 2018; Choi and Qi 2019). Making the ETS more effective in spurring de-carbonization requires imposing a carbon tax as a floor on permit prices, adjusting carbon emission quotas, removing fossil fuel subsidies and introducing more stringent emission regulations (Choi and Qi 2019; Sonneschein and Mundaca 2016).

Even before the Great Recession, there has been a rise in the number of national and sub-national emission trading and carbon taxing schemes throughout the world, and especially in Europe. The World Bank (2019) estimates that around 20% of global emissions are covered by a carbon price, in the form of a carbon tax or trading system, which raise over $40 billion in revenues. A review of ETSs in eight jurisdictions - the European Union (EU), Switzerland, the Regional Greenhouse Gas Initiative (RGGI) and California in the US, Québec in Canada, New Zealand, the Republic of Korea and pilot schemes in China – found encouraging signs that the newer schemes have benefited significantly by learning from prior systems, especially the EU ETS (Narassimhan et al. 2018). However, others analyzing long-term use of carbon pricing, especially in Norway, Sweden and other European countries, which were in place even before the Great Recession, maintain that "deep decarbonisation may not be attained through carbon pricing alone, and that regulations, financial incentives, and public and private investment therefore play important roles on the path towards the global 1.5 °C and 2 °C targets" (Tvinnereima and Mehling 2018, p. 188). Consequently, just as public spending alone may not green an economy over the long term, the corollary lesson here is that carbon pricing on its own may not achieve.

KEY TRENDS SINCE THE GREAT RECESSION

3

Building a greener post-pandemic recovery will also require taking into account some key trends in the world economy since the Great Recession.

One consequence of the green stimulus efforts during the Great Recession, especially by major Asian economies, is that it spurred interest in green industrial policy worldwide (Altenburg and Assmann 2017; Fankhauser et al. 2013; Harrison et al. 2017; Rodrik 2014). Both during and after the Great Recession, this quickly led to a competitive "green race" over global dominance of several key sectors (Fankhauser et al. 2013), such as conventional industrial processes, which need to become cleaner and more resource efficient (e.g. iron and steel); sectors that are important for energy efficiency on the supply side (electricity distribution systems) and the demand side (domestic appliances); the energy supply chain for electricity generation and other industrial processes (steam generators; engines and turbines; electric motors and transformers); and car manufacturing (low-emission and electric vehicles) and key components (accumulators, primary cells and batteries). Fankhauser et al. (2013) find that the "green race" to become global competitive leaders in these industries is between eight G20 economies – China, France, Germany, Italy, Japan, South Korea, the United Kingdom and the United States. However, it is generally the Asian economies that have seized on the innovation and investments necessary to become competitive in this "green race" (Altenburg and Assmann 2017; Fankhauser et al. 2013; Harrison et al. 2017; Rodrik 2014).

For example, South Korea has tried to tie its industrial strategy to green growth (Barbier 2010a; Hwang et al. 2014; Mathews 2012). In addition to the Green New Deal adopted during the Great Recession, the South Korean government established a US$72.2 million renewable energy fund to attract private investment in solar, wind and hydroelectric power projects. This green industrial policy has had some limited success. By the end of the five-year plan, South Korea emerged with a competitive advantage and significant green innovation in basic chemical industries (excluding fertilizer) and special purpose machinery (Fankhauser et al. 2013). As part of its transition to a low-carbon economy, South Korea also planned to develop green technologies to manufacture fuel cells, heat pumps and high efficiency lighting (Hwang et al. 2014). In this regard, one of the successes of the Korean green industrial strategy has less to do with the high-profile infrastructure projects of the Green New Deal but other programs that support green research and development (R&D) tax credits and allowances, tax reductions for the wages of R&D workers and accelerated depreciation of capital used for R&D, which at 0.3% of GDP has created one of the highest levels of support among major economies (Jones and Yoo 2012).

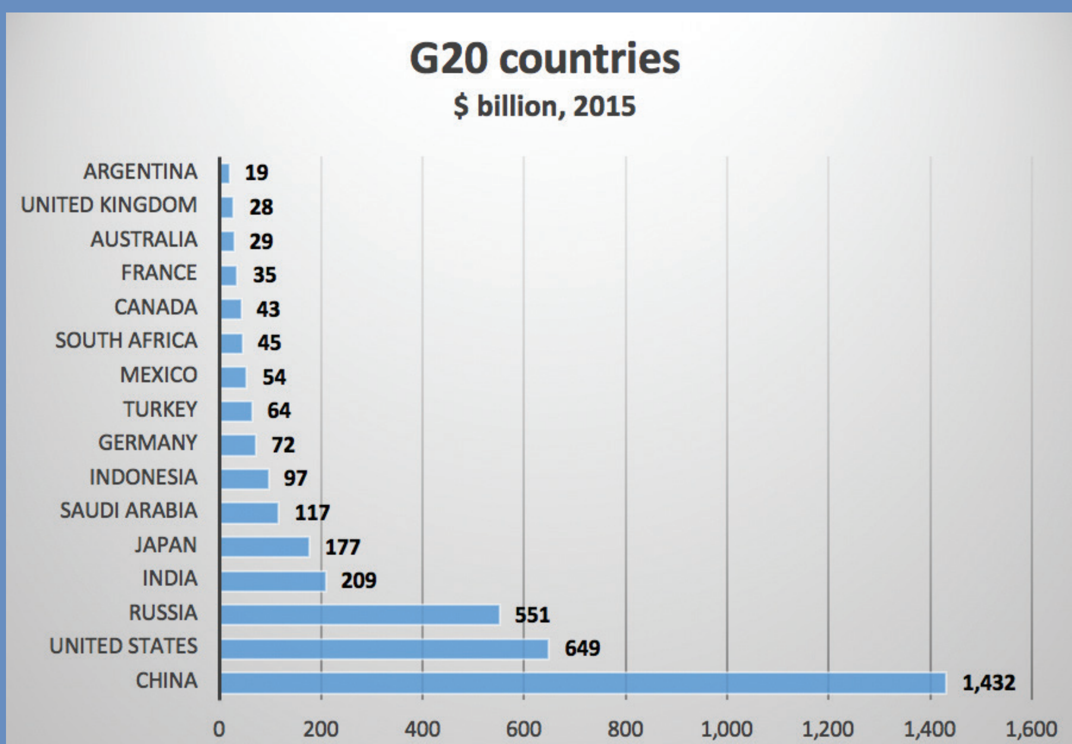
However, the biggest obstacles inhibiting green structural transformation are two persistent market disincentives in all major economies: the persistent underpricing of fossil fuels and market failures that inhibit green innovation.

Perhaps the most comprehensive estimate of the underpricing of fossil fuels is the "post-tax" subsidies approach adopted by International Monetary Fund

(IMF) researchers (Coady et al. 2017 and 2019; Parry et al. 2014). Their method is based on calculating differences between actual consumer fuel prices and how much consumers would pay if prices fully reflected supply costs plus the taxes need to address environment damages, such as the costs of climate change, local pollution, traffic congestion, accidents and road damage, and revenue requirements. Globally, the underpricing of fossil fuels continue to be large at $4.9 trillion (6.5% of global GDP) in 2013, $4.7 trillion (6.3% of GDP) in 2015 and $5.2 trillion (6.5% of GDP) in 2017 (Coady et al. 2017 and 2019).

The persistent underpricing of fossil fuels globally is the most significant deterrent to green structural transformation and innovation. Such underpricing means that there is not a level playing field between fossil fuel and clean energy investments, as fossil fuels do not face the full social and economic costs of their development and use. It is especially a problem for G20 economies - subsidies and the failure to include the carbon, environmental and health damages of fossil fuels costed 16 G20 economies around $3.2 trillion annually in 2015 - which accounted for 70% of the global underpricing of fossil fuels (Coady et al. 2019). In China, underpricing amounted to over $1.4 trillion each year, in the United States nearly $650 billion, in Russia over $550 billion, in India almost $210 billion and in Japan over $175 billion (see Figure 3). Other non-G20 economies that also face serious underpricing of fossil fuels include Iran ($111 billion annually), Ukraine ($61 billion), Thailand ($40 billion), Kazakhstan ($29 billion) and United Arab Emirates ($22 billion) (Coady et al. 2019).

FIGURE 3. THE UNDERPRICING OF FOSSIL FUELS IN G20 ECONOMIES



Source: Coady et al. (2019).

The underpricing of fossil fuels has certainly contributed to rising carbon emissions globally and to the ongoing threat of global warming. But the majority of the environmental and economic costs caused by such underpricing are borne locally within countries through air pollution deaths, morbidity and congestion costs, excessive fiscal spending, and consumption and supply inefficiencies (Parry et al. 2014). For example, if in 2015 fossil fuels were properly priced, estimated global CO2 emissions would have been 28% lower, fossil fuel air pollution related deaths 46% lower, and fiscal revenues $2.8 trillion higher (3.8% of global GDP) (Coady et al. 2019).

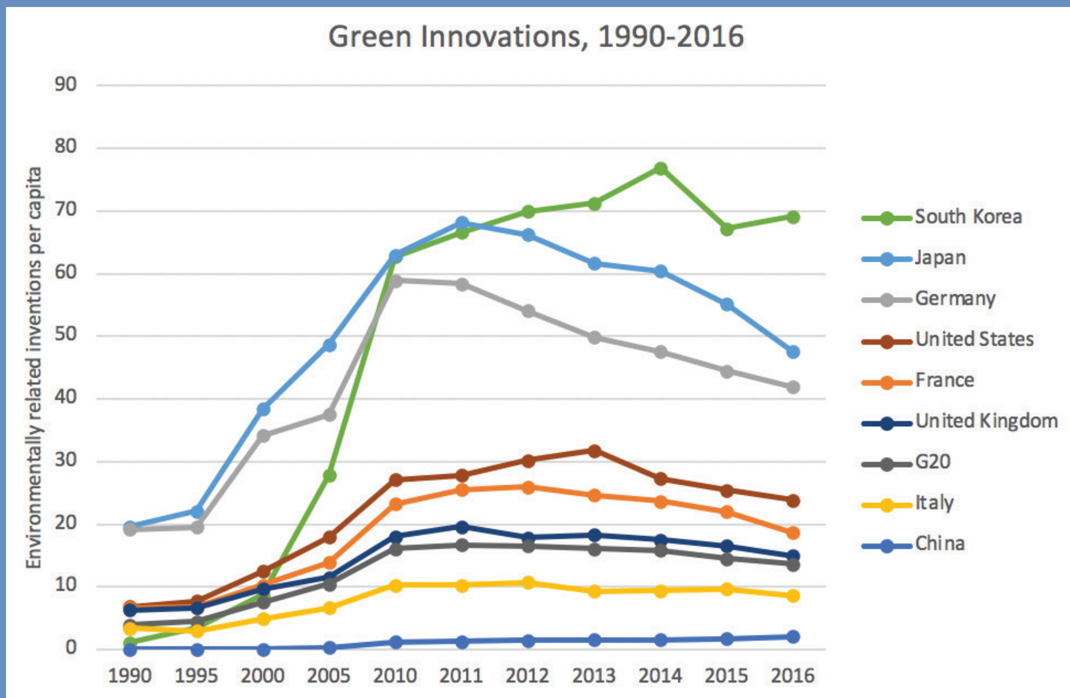
An important impetus for rapid economy-wide innovation is "technology spillovers". These occur when the inventions, designs and technologies resulting from the research and development (R&D) activities by one firm or industry spread relatively cheaply and quickly to other firms and industries. These include cross-firm externalities, industry-wide learning, skill development, or agglomeration effects. However, spillovers also undermine the incentives for a private firm or industry to invest in R&D activities. For instance, a private investor bears the full costs of financing R&D and may improve its own technologies and products as a result, but the investor receives little or no returns from the subsequent spread of these innovations throughout the economy. The consequence is that private firms and industries routinely under-invest in R&D, and the result is less economy-wide innovation overall.

As pointed out by Rodrik (2014, p.470), such market disincentives for investing in innovation "exist in general for all kinds of new technologies, whether they are of the green or dirty kind. However, their novelty, their highly experimental nature, and the substantial risks involved for pioneer entrepreneurs suggest green technologies may be particularly prone to these failures." For example, market disincentives are found to be a deterrent to clean energy innovation and development in both emerging market economies and North America (Barbier 2016a; Harrison et al. 2017). Even among the major economies involved in the "green race" to become competitive leaders globally, economy-wide green innovation falls well short of the level necessary to generate structural transformation (Fankhauser et al. 2013).

Figure 4 indicates how environmental innovations per capita have been declining in recent years in the G20 and the green race economies, with the exception of South Korea and China. This decline is important, as just four of these economies account for nearly two thirds of the green technologies worldwide – the United States (24%), Japan (19%), Germany (11%) and South Korea (11%).[4]

4 Based on development of environmentally related technologies, % inventions worldwide, 2016 from OECD (2020), "Green growth indicators", OECD Environment Statistics https://doi.org/10.1787/data-00665-en .

FIGURE 4. ENVIRONMENTALLY RELATED INVENTIONS PER CAPITA, 1990-2016



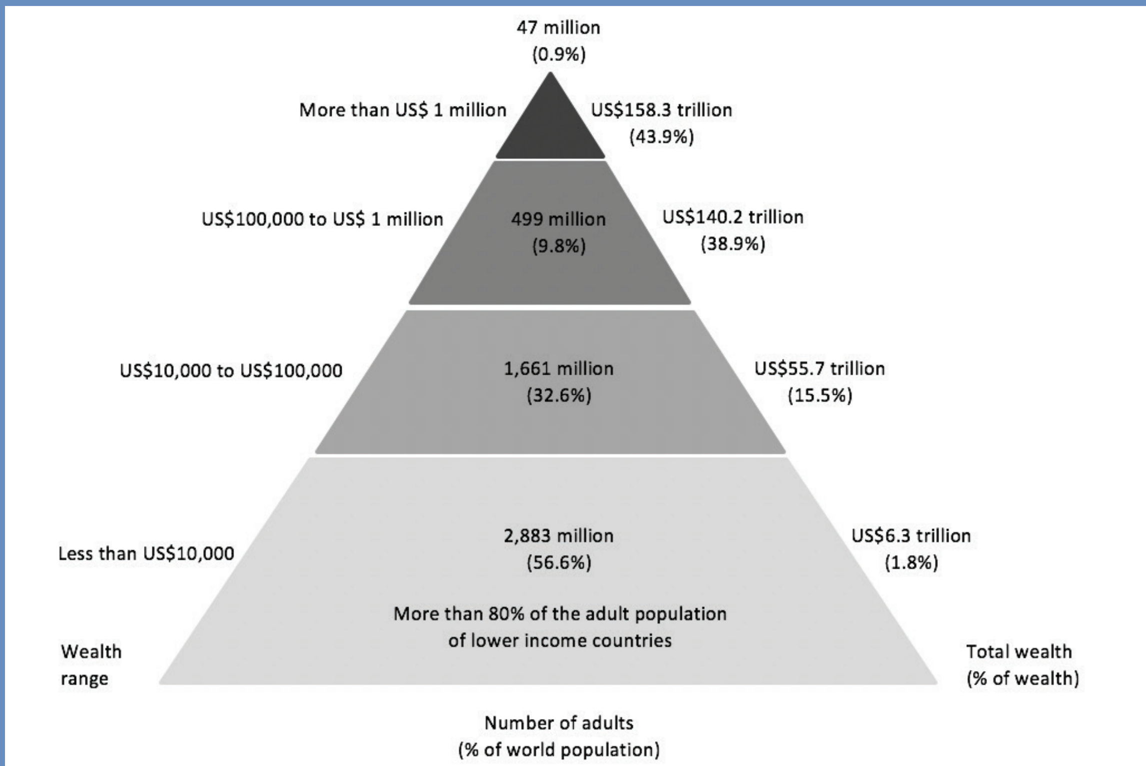
Source: OECD (2020), "Green growth indicators", OECD Environment Statistics https://doi.org/10.1787/data-00665-en

Another key global trend is that economic growth has become less inclusive. Since 1980, there has been rising inequality in most of the world's regions, as the top 10% increased their share of income (Alvaredo et al. 2017). A major factor has been the unequal distribution of the growth in global income over past decades between the rich and poor. While the poorest half of the global population has seen its income grow significantly, especially in China, India and other Asian countries, since 1980 the top 1% richest individuals in the world captured twice as much growth as the bottom 50% (Alvaredo et al. 2017).

The lack of inclusive growth has also contributed to increasing wealth inequality (Shorrocks et al. 2019). Much of this inequality is due to variations in average wealth across countries, but there is also considerable disparity within nations. As with income, the result is that the rich are getting richer, and acquiring a greater share of global wealth.

Figure 5 provides a snapshot of the current global wealth distribution. Around 2.9 billion people in the world, around 57% of the world's population, have wealth of less than US$10,000. More than 80% of the adults of lower income countries fall within this lowest wealth range. In comparison, people who are millionaires or richer comprise less than 1% of the world's population yet they own 44% of global assets. What is more, the aggregate wealth of these high net worth individuals has grown nearly four-fold from US$ 39.6 trillion in 2000 to US$158.3 trillion in 2019, which increased their share of global wealth by 5% (Shorrocks et al. 2019).

FIGURE 5. THE GLOBAL WEALTH PYRAMID, 2019



For the 47 million high net worth individuals at the apex, the wealth of 41.1 million ranges from US$1 million to 5 million, 3.7 million from US$5 to 10 million, 1.8 million from US$10 to 50 million, and 168,030 more than US$50 million.

Source: Shorrocks et al. (2019).

As wealth inequality has increased, its composition has changed dramatically. Since 1980, very large transfers from public to private wealth occurred in nearly all countries, whether high income, emerging or lower income (Alvaredo et al. 2017). While private wealth has increased substantially, net public wealth (public assets minus debt) has declined and is even negative for some major economies. The rapid rise in public debt gives governments less room to maneuver in terms of managing the economy, and also constrains funding for public programs to distribute income and mitigate inequality, public services to support vulnerable households, the unemployed and public education, health transport, and long-term strategic investments in public infrastructure necessary for green transitions. Widespread and growing public debt will also make it harder for the international community to mobilize "maximum financial and technical support for the poorest and most vulnerable people and countries hardest hit" (UN 2020, p. 1). Finally, higher debt incurred during the COVID-19 pandemic appears to be correlated with poorer long-term economic and health outcomes in emerging economies, as recent evidence shows that "economies that start the outbreak with more debt will suffer more severe health and debt crises: more fatalities and more prolonged defaults" (Arellano et al. 2020, p. 4).

The latter concern is directly relevant to the attainment of the UN's 2030 Agenda for Sustainable Development, which provides a framework for "peace and prosperity for people and the planet, now and into the future" (UN 2015). The centerpiece of Agenda 2030 is the 17 Sustainable Development Goals (SDGs), which "aim for a combination of economic development, environmental sustainability, and social inclusion", especially for the poorest countries and people (Sachs 2012, p. 2206).

Progress in attaining all 17 SDGs has been mixed (Barbier and Burgess 2019; UN 2019; Moyer and Hedden 2020). Although extreme poverty and infant and maternal mortality have declined since 2000, low-income countries have achieved less poverty reduction, and this progress came at the expense of other important goals, especially the five "environmental" SDGs 11-15 that relate to climate change, land use, oceans, sustainable consumption and other environmental concerns (Barbier and Burgess 2019).

We are also a long way from achieving key sustainability and development objectives for the most vulnerable people and countries. 736 million people still live in extreme poverty, 821 million are undernourished, 785 million people lack even basic drinking water services, and 673 million still practice open defecation (UN 2019). About 3 billion people lack clean cooking fuels and technology, and of the 840 million people without electricity, 87% live in rural areas. 28 poor countries are unlikely to attain SDGs 1-4, 6 and 7 by 2030 (Moyer and Hedden 2020).

To summarize, several global trends since the 2008-9 Great Recession must be considered when devising a post-COVID green recovery strategy. These include:

- major market disincentives, especially the underpricing of fossil fuels and market failures that inhibit green innovation;
- widening wealth and income inequality, the growth in private wealth while public debt rises; and
- the lack of progress in achieving key Sustainable Development Goals (SDGs).

BUILDING A GREENER RECOVERY FOR THE G20

4

The G20 economies are at the center of the concern over how the world economy should recover from the coronavirus. They account for nearly two thirds of the world's population and land area, 82% of GDP and 80% of global CO2 emissions.[5] As noted previously, the G20 also dominate the "green race" for environmental competitiveness and innovation in key global industries, such as machinery, motor vehicles, engines and turbines, steam generators, iron and steel, batteries, electricity generation and distribution, and domestic appliances (Fankhauser et al. 2013). Thus, greening the post-pandemic recovery in the G20 will have important implications not just domestically but also for the future structure of the world economy, the generation of employment, the distribution of wealth and income, and the mitigation of global climate and other environmental risks.

As mentioned before, the biggest obstacles to sustaining long-term green structural transformation after the COVID-19 crisis abates in G20 economies are major market disincentives, especially the underpricing of fossil fuels and market failures that inhibit green innovation. Overcoming these obstacles will involve two steps. First, removing fossil fuel subsidies and employing carbon and other green taxes to further reduce the social costs of fossil fuel use. Second, allocating any resulting revenue to public support for green innovation and key infrastructure investments.

The most significant deterrent to a sustainable and inclusive green recovery is the persistent underpricing of fossil fuels. Current markets for coal, oil and natural gas, as well as for their key products – electricity generation, diesel and gasoline – not only exclude these environmental damages and other impacts, but the prices in these markets are frequently subsidized in G20 economies (Barbier 2016 and 2020; Coady et al. 2017 and 2019; Gençsü et al. 2019; IEA 2019 and 2020; IISD 2019b; Parry et al. 2014; Whitley et al. 2018). For example, although coal-fired power plants are the single largest contributor to the growth in global CO2 emissions, annual support for coal by G20 governments includes $27.6 billion in public finance, $15.4 billion in fiscal support and $20.9 billion in state-owned enterprise investments (Gençsü et al. 2019). In addition, there are significant annual subsidies for the exploration and exploitation of new reserves of fossil fuels (Bast et al. 2014).

The persistent underpricing of fossil fuels also substantially distorts the attractiveness of investing in and using these sources of energy compared to clean energy alternatives. The cost of renewable energy, especially solar and wind, has declined considerably in recent years, and reached levels of market competitiveness with fossil fuels, most notably in electricity generation (Lazard 2019). As the IISD (2019a, p. 6) notes, "If governments maintain policies that support fossil fuels", thus artificially trying to widen the gap between the costs between renewables and fossil fuel-based energy, then "taxpayers will be left with a growing fiscal burden to fund the difference." More importantly, if G20 economies continue with public funding of exploration, production, consumption and other fossil fuel subsidies, as well as fail to effectively price carbon and pollution, they are further retarding the transition to a clean energy economy (Barbier 2010b and 2016).

5 From the World Bank's World Development Indicators http://databank.worldbank.org/data/databases.aspx.

Ending the underpricing of fossil fuels in G20 economies would not only remove a major market disincentive to green structural transformation and innovation but also raise substantial revenue. As noted above, 16 G20 economies account for around 70% of the global underpricing of fossil fuels (see Figure 3). Based on the estimates by Coady et al. (2019) of the revenues generated globally from ending this underpricing, the G20 could raise $1.94 trillion annually, or around 3.7% of their aggregate real GDP (Barbier 2020a).

Yet, despite the overwhelming evidence of the harm from underpricing fossil fuels, governments are generally hesitant to end subsidies and adopt carbon pricing. One persistent problem is that taxes and subsidies are still largely viewed as instruments of fiscal, and not environmental or climate, policy. For example, a study of gasoline taxes and subsidies in 157 countries from 2003 to 2015 found that, despite rising alarm about climate change, there was little net change in fuel taxes and subsidies across countries, which were largely driven by macroeconomic factors such as income per capita, fossil fuel wealth and government debt (Mahdavi et al. 2020). That is, fossil fuel taxation is still determined by a government's income and revenue needs, and not for attaining environmental or climate objectives.

Although it is unlikely for full efficient pricing to be implemented for fossil fuels in G20 economies, pricing reforms that remove exploration, consumption and other public subsidies, as well as taxing carbon and other pollutants, could nonetheless raise significant revenues over many years. These funds could be used to support green R&D and innovation and other critical long-term public investments. Even partial pricing reforms could "tip the balance" between fossil fuels and cleaner sources of energy.

For example, IISD (2019a) maintains that a 10-30% subsidy swap from fossil fuel consumption to investments in energy efficiency and renewable energy electricity generation could substantially improve the transition to a low-carbon economy. Already, some progress along these lines been made in two emerging market G20 economies, India and Indonesia. A study of 26 countries – 10 of which are in the G20 – found that the removal of fossil fuel subsidies on its own reduces greenhouse gas emissions by 6 percent on average for each country from 2018 until 2025 (IISD 2019b). [6]

However, utmost care is needed in ensuring that any fossil fuel subsidy reform is complemented by other policy measures that mitigate potential short-term negative effects on poorer and more vulnerable households, who might be adversely affected by the subsidy removal. This can be done through revenue recycling for direct cash transfers or income dividends, for example. Countries undertaking fossil fuel subsidy reform need to pay close attention to the design, sequencing and communication of such a policy to ensure long-term success and avoid the significant political challenges involved.

The World Bank (2019) suggests that a carbon tax or emissions trading scheme price within the range of US$40 to US$80 per tonne of carbon dioxide-equivalent (tCO2e) is the minimal price range[7] consistent with achieving the Paris Agreement temperature target. As shown in Figure 6, only five countries have carbon tax schemes that conform to that range. These are Sweden, Switzerland, Finland, Norway and France. However, besides France, only four other G20 economies have adopted any national carbon pricing policies – Argentina, Japan, Mexico and the United Kingdom. Consequently, there is considerable scope for G20 economies to adopt carbon pricing that would both assist them achieving

6 The 10 G20 economies are Brazil, China, Germany, India, Indonesia, Mexico, Russia, Saudi Arabia, South Africa, and the United States.

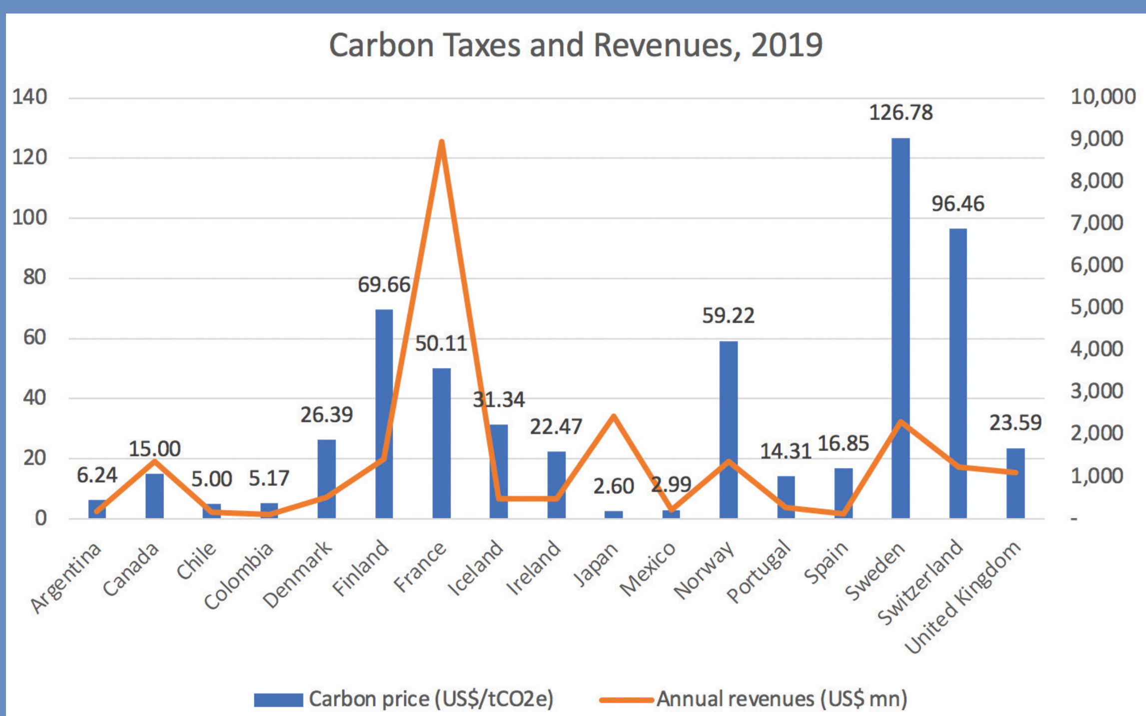
7 In 2019 there were also four large carbon emissions trading schemes (ETS) with a significant carbon price, although not within an average price within the desired US$40-80/tCO2e range. They include the ETS for the European Union ETS (carbon price US$24.51/tCO2e, annual revenues US$16,011 mn), New Zealand (US$17.53, US$251 million), South Korea (US$23.46, US$179 million) and Switzerland (US$7.18, US$9 mn). From World Bank, Carbon Pricing Dashboard https://carbonpricingdashboard.worldbank.org/map_data

their commitments to the Paris Agreement and raise significant annual revenues to fund additional long-term green investments.

For example, based on Resources for the Future (RfF)'s E3 Carbon Tax Calculator (Hafstead 2019), if the United States adopted a $40 per tonne tax rising at 1% per year above inflation, it could reduce cumulative US emissions by 19.5 billion tonnes over 2020-2035 and raise ,on average, $160 billion per year in revenues (Barbier 2020a). Moreover, analysis of the macroeconomic implications of imposing such a carbon tax rate finds no adverse, and possibly even positive, impacts on GDP and overall employment (Metcalf 2019; Metcalf and Stock 2020).

The second market failure that needs to be addressed in G20 economies is the lack of sufficient public sector support for green research and development (R&D) leading to innovation. Moreover, overcoming this disincentive cannot be achieved solely by the use of market-based incentives to correct inefficient pricing but requires the simultaneous implementation of "technology-push policies", such as research and development (R&D) subsidies, public investments, protecting intellectual property, and other initiatives (Acemoglu et al. 2012; Barbier 2016; Goulder 2004). Market-based incentives may reduce pricing distortions that put green goods and services at a competitive advantage. However, only technology-push policies directly address the tendency of firms and industries to under-invest in green R&D. Thus, a strategy for a green economic transition must include correcting market disincentives as well as a long-term commitment of public sector support and funding for private green R&D and innovation.

FIGURE 6. CARBON TAXES AND REVENUES IN SELECTED COUNTRIES, 2019

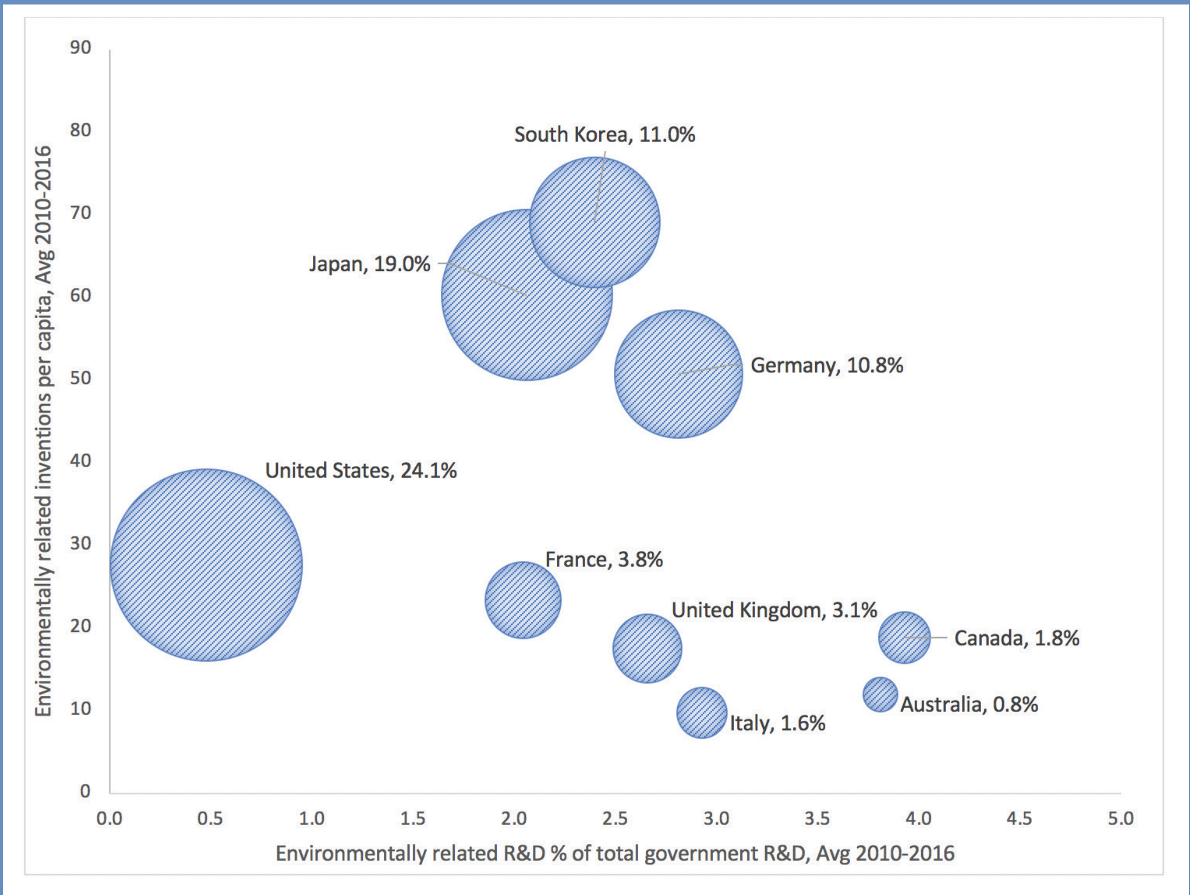


Six other countries also had smaller carbon tax schemes in 2019, generating less than $100 million annually in revenues. They include Slovenia (carbon tax US$19.44/tCO2e, annual revenues US$81 mn), Ukraine (US$0.37, US$48 mn), Latvia (US$5.06, US$9 mn), Liechtenstein ($96.46, $4 mn), Estonia (US$2.25, US$3 mn) and Poland (US$0.08, US$1 mn).

Source: World Bank, Carbon Pricing Dashboard https://carbonpricingdashboard.worldbank.org/map_data

Figure 7 indicates some of the effects of public sector support for green research and development for nine major economies. Together they account for over three-quarters of the world's environmentally related inventions. Germany, Japan, South Korea and the United States are responsible for nearly 44% of green innovation globally. However, public sector support for green R&D remains extremely low for these major innovating economies, ranging from just under 0.5% of the total government R&D budget in the United States to 3.9% in Canada. What is more, with the exception of Japan and South Korea, the share of government R&D devoted to environmentally related innovation has fallen since 2000.

FIGURE 7. PUBLIC SUPPORT FOR GREEN R&D, SELECTED COUNTRIES



The size of the bubble indicates the share of each country to environmentally related technological inventions worldwide in 2016. The nine countries accounted for 75.9% of environmentally related inventions worldwide. Germany, Japan, South Korean and the United States accounted for 43.9% of worldwide inventions. The other major environmental innovator is China, which had 9.3% of the world's environmentally related inventions in 2016. In 2010, the share of global green innovations for Australia was 0.9%, Canada 2.1%, China 4.6%, France 4.1%, Germany 13.3%, Italy 1.7%, Japan 22.6%, South Korea 8.7%, United Kingdom 3.2% and the United States 23.4%.

Over 2010-2016, the share of environmentally related R&D in total government R&D support increased by 290% in Japan and by 28% in South Korea, while decreasing by 2% in Germany, 7% in Canada, 12% in Australia, 18% in the United States and 20% in the United Kingdom.

Source: OECD (2020), "Green growth indicators", OECD Environment Statistics https://doi.org/10.1787/data-00665-en

Two economies that have actively pursued policies to support green innovation through expanded government support have been China and South Korea. Although there are no data available on the extent of public support for China, over 2010-2016 China doubled its share of environmentally related inventions worldwide (see Figure 7). Over 2000-2016 South Korea increased its share of government R&D devoted to environmental technologies by 28%. As a result, over this period South Korea's share of global green innovation has increased from 8.7% to 11.0% and it is now producing nearly 70 environmentally related inventions per person.

More public investment to support green innovation will require additional funding by all G20 governments. But there is good news, too, on the costs of promoting clean energy and other environmentally related technologies. Gillingham and Stock (2018) suggest that the high costs today of reducing carbon emissions through some low-carbon technologies could fall quickly if the right policies are adopted.

Expenditures targeted at clean energy research and development will lead to lower costs and wider adoption, as the technology becomes more familiar, innovation spreads, and production scales up. Gillingham and Stock (2018) cite the rapid fall in solar panel costs as one example. There is also a network effect where increasing demand for a clean-energy technology or product fosters related innovations that lower cost. For example, purchases of electric vehicles will stimulate demand for charging stations, which once installed will reduce the costs of running electric vehicles and further boost demand. This suggests that subsidies for purchasing electric vehicles can kick-start this network effect but should be phased out once the effect takes hold.

However, public support and investments may also be critical for the removal of other bottlenecks to green structural transformation of G20 economies. For example, one obstacle across all economies is inadequate transmission infrastructure for renewables. This can only be overcome through public investments to design and construct a "smart" electrical grid transmission system that can integrate diffuse and conventional sources of supply. A solution is urban development policies that combine municipal planning and transport policies for more sustainable cities. Finally, public investment in mass transit systems, both within urban areas and major routes connecting cities has been a long-neglected aspect of public infrastructure development throughout many economies. These and other areas of possible long-term investments for a green recovery are important areas for future research.

Finally, G20 countries with substantial tropical areas, such as Australia, Brazil, India, Indonesia and Mexico, should also consider adopting a "tropical carbon tax" (Barbier et al. 2020). This is a levy on fossil fuels that is invested in natural climate solutions (NCS) aimed at conserving, restoring and improving land management to protect biodiversity and ecosystem services. NCS are a relatively inexpensive way of reducing tropical land use change, which is a major source of greenhouse gas emissions. For example, cost-effective tropical NCS can mitigate 6,560 106 tonnes of CO2e in the coming decades at less than $100 per 103 tonnes of CO2e, which is about one quarter of emissions from all tropical countries (Griscom et al. 2020). Costa Rica and Colombia have already adopted a tropical carbon tax strategy. If a policy similar to Colombia's was put in place by India, it could raise $916 million each year to invest in natural habitats that benefit the climate; similarly, Brazil could raise $217 million annually, Mexico $197 million and Indonesia $190 million (Barbier et al. 2020). A more ambitious policy of taxation and revenue allocation could yield nearly $6.4 billion each year for natural climate solutions in India, $1.5 billion for Brazil, $1.4 billion for Mexico and $1.3 billion for Indonesia.

Natural climate solutions, such as reversing deforestation, reforestation, increasing soil carbon levels and enhancing wetlands, are increasingly considered cost-effective investments for mitigating greenhouse gas emissions from land use for temperate G20 economies as well (EASAC 2019; Fargione et al. 2018; Griscom et al. 2017). NCS can provide over one-third of the cost-effective climate mitigation needed by 2030 to stabilize warming to below 2°C, with one third of this mitigation costing $10 per 103 tonnes of CO2e or less (Griscom et al. 2017). At this cost, the United States could abate 299 million tonnes CO2e of greenhouse gas emissions annually through NCS, which would also provide other benefits, such as air and water filtration, flood control, soil conservation and wildlife habitats (Fargione et al. 2018).

To summarize, the lack of public sector support for private green R&D and insufficient public investments to overcome other obstacles to long-run green transitions in G20 economies are serious impediments that need to be addressed. However, it may prove difficult to raise additional funds for sustaining additional public investments over the next 5-10 years to "green" the recovery in this way. For example, the International Energy Agency has proposed a three-year plan of recovery through similar investments of about US$1 trillion annually, or about 0.7% of global GDP (IEA 2020). Given the cumulative shortfall of up to $30 trillion by 2023 (Assi et al. 2020), most of which will be borne by G20 economies, there is an urgent need for research into the design of policies, such as a carbon tax, to correct market disincentives as well as generate revenues for longer term essential expenditures on public support for green innovation and key infrastructure investments for a post-coronavirus recovery.

The upshot is that the combination of fossil fuel subsidy removal and carbon and other environmental taxes could correct market disincentives that deter de-carbonization as well as provide revenues for 5-10 years of necessary expenditures on public support for green innovation and key infrastructure investments in G20 economies.

BUILDING A GREENER RECOVERY FOR LOW AND MIDDLE-INCOME COUNTRIES

5

The special circumstances faced by low and middle-income countries require a post-pandemic strategy that needs to translate into immediate sustainability and development progress.

COVID-19 has hit developing countries particularly hard (Ahmed et al. 2020; Barbier and Burgess 2020; Sumner et al. 2020; UN 2020). A preliminary assessment by the UN suggests that the pandemic is likely to adversely impact progress towards 12 of the 17 SDGs (UN 2020). This should be of considerable concern. As we saw previously, even before the pandemic, progress towards the SDGs had been mixed, especially for the most vulnerable populations and the poorest countries (Barbier and Burgess 2019; UN 2019; Moyer and Hedden 2020).

The UN Secretary General has called for "coordinated, decisive, and innovative policy action from the world's leading economies, and maximum financial and technical support for the poorest and most vulnerable people and countries, who will be the hardest hit" (UN 2020, p. 1). However, additional financial support to aid low and middle-income countries in their recovery efforts may not be forthcoming, as the global debt is projected to be $30 trillion by 2023 (Assi et al. 2020).

Given this likely financial scenario, it is critical that developing countries find innovative policy mechanisms to achieve sustainability and development aims in a cost-effective manner. This requires identifying policies that can yield immediate progress towards several SDGs together, rather than sacrificing some goals to achieve others, and aligns economic incentives for longer term sustainable development. Policies should also raise or save revenue, generate the necessary funding for any additional investments, and have a proven track record.

A range of innovative policies meet these criteria. These include "subsidy swaps", investment in natural capital, social protection and safety nets, sustainable intensification in agriculture, and job and skills training. Given the priority for impactful policies that create synergies with other SDGs, there are three major policies that developing countries can adopt immediately to achieve these objectives without significant additional financial support from the international community (Barbier and Burgess 2020).

First, like the G20 economies, low and middle-income countries could implement a "subsidy swap" for fossil fuels, whereby the savings from subsidy reform for coal, oil and natural gas consumption are allocated to fund clean energy investments (IISD 2019a). In 2018, fossil fuel consumption subsidies reached $427 billion annually, of which nearly $360 billion were in developing countries (this is without factoring for externalities).[8] As discussed previously, a 10-30% subsidy swap from fossil fuel consumption to investments in energy efficiency and renewable energy electricity generation could "tip the balance" between fossil fuels and cleaner sources of energy (IISD 2019a). Partial reforms in India, Indonesia, Morocco and Zambia have already shown some progress. IISD (2019b) shows that removal of fossil fuel subsidies on its own in 26 countries – 22 of which are low and middle income – would reduce greenhouse gas emissions by 6 percent on average for each country.

8 From https://www.iea.org/topics/energy-subsidies. Accessed on May 8, 2020.

However, there is an additional important use of the savings from subsidy removal in low and middle-income countries. In poorer economies, a fossil fuel subsidy swap should also be used to facilitate greater dissemination and adoption of renewable energy and improved energy efficiency technologies in rural areas. It could also be used to support the adoption of clean cooking and heating technologies (IEA 2020). This is critical for reducing energy poverty across developing countries (Casillas et al. 2010; Rogelj et al. 2013; Pahle et al. 2016; Barbier 2020b). Morocco, Kenya, South Africa illustrate how different public policy approaches can facilitate the adoption and deployment of renewable energy and improved energy efficiency technologies in rural areas (Pahle et al. 2016; Barbier 2020b).

A fossil fuel subsidy to support energy efficiency and renewable energy in rural areas would also have important equity gains. In low and middle-income economies, it is mainly wealthier, urban households that benefit from fossil fuel consumptions subsidies, whereas it is rural households that increasingly comprise the extreme poor (Castañeda et al. 2018). Across 20 developing countries, the poorest fifth of the population received on average just 7% of the overall benefit of fossil fuel subsidies, whereas the richest fifth gained almost 43% (Arze del Granado et al. 2012).

Second, developing countries could also implement a “subsidy swap” for irrigation to support investments in clean water and improved sanitation. Irrigation subsidies lead to over-use of water, inefficiencies and inequality, as irrigation is often allocated by land holding area and thus any subsidies disproportionately benefit larger and wealthier farmers (Gany et al. 2019). Two types of subsidies are frequently employed (Kjellingbro and Skotte 2005; Ward 2010; Brelle and Dressayre 2014; Toan 2016). Irrigation water is often priced below its cost of supply and may not even cover the operation and maintenance costs of irrigation systems. A conservative estimate of such subsidies in developing countries is $30 billion per year (Kjellingbro and Skotte 2005). Irrigation also benefits from cross-subsidies from power generation, whereby buyers of hydroelectricity pay for the dam and other infrastructure and the stored water is allocated to irrigation with little cost recovery. Although the amount of such cross-subsidies is unknown, they are used frequently in low and middle-income countries (Ward 2010; Brelle and Dressayre 2014).

Reallocating irrigation subsidies to improve water supply, sanitation and wastewater infrastructure is an urgent need in all developing countries (Whittingon et al. 2008; Grigg 2019; Hope et al. 2020). The strategy for targeting and sequencing water-related services in developing countries should prioritize the needs and income levels of the intended beneficiaries, their ability to pay for improved clean water and sanitation, and the overall costs of providing clean water and sanitation services. For example, three small-scale interventions that do not involve large-scale infrastructure and supply networks for delivering clean water and sanitation include rural water supply programs that provide communities with deep boreholes and public hand pumps, community-led total sanitation campaigns, and biosand filters for household water treatment (Whittington et al. 2008). These interventions are not only affordable for poor households and communities but could also generate essential health and economic benefits post-pandemic, and protect women and children, who are worst affected by a lack of clean water and sanitation. Both boreholes and biosand filters can be scalable for large number of communities in developing countries, and the filters can be used by households in both rural and low-density urban areas. The resulting cost reductions make such interventions affordable and facilitate user payments even in the poorest regions, such as rural Africa (Hope et al. 2020).

Lastly, developing countries could also consider adopting a "tropical carbon tax" as outlined above (Barbier et al. 2020). Costa Rica and Colombia have already adopted a tropical carbon tax strategy. If 12 other megadiverse countries roll out a policy similar to Colombia's, they could raise $1.8 billion each year between them to invest in natural habitats that benefit the climate (Barbier et al. 2020). A more ambitious policy of taxation and revenue allocation could yield nearly $13 billion each year for natural climate solutions.

Moreover, such a strategy can be "pro-poor". Ecosystem services such as drinking-water supply, food provision and cultural services are estimated to contribute between 50% and 90% of income and subsistence among the rural poor and those who live in forests (CBD 2019). Such services can make an important contribution to ending extreme poverty (SDG 1), achieving zero hunger (SDG 2), improving health (SDG 3) and meeting many of the other 14 SDGs.

Together, these three policies can make an important contribution towards meeting immediate SDG objectives, such as boosting economic activity, job creation, poverty reduction, environmental improvement, and support of health care needs. Moreover, they do so in a cost-effective manner that raises rather than requires scare financial resources. These policies also provide strategic support for the development of a solid framework of incentives for long-term sustainable development. However, recent evidence indicates that policy makers may be focusing on one or two goals, such as boosting the economy and job creation, at the expense of other goals, such as reducing carbon emissions and tropical forest conservation, and overall sustainable development objectives. Furthermore, political unrest and instability makes the ability to adopt and implement any such policy options more challenging. Finally, the uncertainty imposed by the COVID-19 pandemic has undermined the resilience of countries, which could affect their willingness to work together for common socio-economic objectives (Oldekop et al. 2020).

6

TOWARDS MORE INCLUSIVE GREEN GROWTH

Ideally, greening the post-pandemic recovery will also put the world economy on a more inclusive growth path, including generating net gains in employment, improving income and wealth distribution, and targeting gains towards vulnerable populations and poor countries. As Section 3 outlined, the worsening inequality trends in the decades leading up to the COVID-19 are essential considerations to address for any green recovery strategy. Ensuring that green growth is inclusive is even more of a priority in the coming decades, given the skyrocketing unemployment and likely disproportionate impacts on low-income households and countries caused by the pandemic.

As the previous section has outlined, the three policies recommended for low and middle-income countries aim to reduce energy poverty, improve income and subsistence among the rural poor, provide basic health services, such as improving access to sanitation, clean water and reducing mortality, and support ecosystem services essential to the livelihoods of the poor. Moreover, much of the funding for these policies is from reallocating subsidies and other market distortions that generally favor the rich.

But it is less clear what an overall transition to a greener economy might entail for employment, the distribution of wealth and income, and poverty.

There is a general presumption that, although there will be some job losses, the net gain in employment is likely to be positive. For example, the New Climate Economy report suggests that a green transition will cause low-carbon employment to rise by 65 million people by 2030, more than offsetting employment losses in declining sectors, leading to a net gain of 37 million jobs (NCE 2018). The ILO (2018) estimates that, limiting climate change to 2°C, would create approximately 24 million jobs at the loss of approximately 6 million jobs, producing a net increase of 18 million jobs by 2030. As the analysis above is mostly pre-COVID-19, it should be juxtaposed with more recent research on the employment implications of the global outbreak and possible recovery plans. The IEA (2020) projects that, three million jobs have been lost or under threat from the pandemic, with another three million lost or in danger in related sectors such as vehicles, buildings and industry. However, the three-year sustainable recovery plan put forward by IEA (2020) could save or create roughly 9 million jobs, mainly through energy efficiency, improving the electricity grids and renewables. In addition, around 420 million people in low and middle-income countries would obtain clean-cooking technologies and nearly 270 million would gain access to electricity.

However, the OECD (2017, p. 11) takes a less sanguine view, arguing that: "Robust empirical evidence of the overall employment effects of ambitious green policies is still lacking. Major transformations of the economy towards green growth are very scarce, and this complicates econometric analysis." Clearly, there is much more work to be done on this crucial research question.

Economic analyses of the possible income and wealth implications of a major transformation to a green economy are even rarer. Structural transformation and technological change towards less-polluting and more resource-efficient economic activities are bound to have significant income and wealth impacts. To some extent, the distribution effects can be offset by policy measures. For example, the Canadian province of British Colombia designed its carbon tax to be revenue-neutral, using any funds raised to reduce corporate and personal income taxes and the burden on low-income households (Metcalf 2019; Yamazaki 2017). Other possible options are to recycle revenues to lessen payroll taxes, pay annual dividends to households, raise the minimum wage, provide payments or retraining for displaced workers, and reduce burdens for vulnerable households affected by the green transition.

These are important policies to consider in addition to using the revenues from removal of fossil fuel subsidies or imposing taxes on carbon and other environmental damages to fund long-term public support for green innovations and key infrastructure investments. The revenues gained from ending the underpricing of fossil fuels could fund both an ambitious strategy of public investments for the green transition as well as a range of policies and programs to offset the distributional consequences of the transition.

For example, the IMF (2020) maintains that containing global warming to 2°C or less would require rapidly phasing in measures equivalent to a global tax of at least $75 per ton by 2030, whereas the current global average carbon price is $2 per ton. According to their calculations, for many countries, a $75 per tonne carbon tax would increase gasoline prices, but the increase in price would be less than the overall decline in global oil prices during the pandemic. For the United States, Barbier (2020a) estimates that a $65 per tonne tax, rising at 1% per year above inflation could reduce cumulative US emissions by 25.6 billion tonnes over 2020-2035 and raise on average $234 billion per year in revenues (1.4% of 2018 real GDP).[9] These revenues should be sufficient to fund long-term commitments (5 to 10 years) of public spending on green innovation and key infrastructure and additional expenditures to reduce the burden on low-income households, displaced workers, lowering payroll taxes, and other measures to reduce employment, income and wealth effects.

In sum, the employment, wealth and poverty implications of a post-pandemic green recovery will become increasingly important dimensions of a policy strategy. There are ways to design the policies and accompanying investments to ensure more equitable and just distributions of benefits.

Ultimately, the aim of any recovery must be inclusive green growth, and the choice of policies and their implementation will be crucial to this objective.

9 The carbon tax and revenue simulations in Barbier (2020a) are based on (Hafstead 2019) and the GDP data are from the World Bank's World Development Indicators http://databank.worldbank.org/data/databases.aspx.

CONCLUSIONS

7

An important lesson from the green stimulus packages enacted during the 2008-9 Great Recession is that policies for a sustained economic recovery amount to much more than just short-term fiscal stimulus. Transitioning from fossil fuels to a sustainable, low-carbon economy after the COVID-19 crisis will require long-term commitments (5 to 10 years) of public spending and pricing reforms.

However, the package of reforms will be different for major economies, such as the Group of 20 (G20), and low and middle-income economies, reflecting their different structural conditions and needs.

For G20 economies, the priorities for public spending are support for private sector green innovation and infrastructure, development of smart grids, transport systems, charging station networks, and sustainable cities. Pricing carbon and pollution, and removing fossil-fuel subsidies, can create the market incentives to accelerate the transition, raise revenues for the necessary public investments, and lower the overall cost of the green transition. Moreover, more ambitious policies to reduce the under-pricing of fossil fuels could raise enough revenues for both public support for green innovation and key infrastructure investments and to mitigate any burdens on low-income households, displaced workers and affected firms, and the unemployed.

The growing financial burden that COVID-19 is placing on all economies means less international funding available for achieving the 17 Sustainable Development Goals (SDGs), climate change mitigation and adaptation, and biodiversity conservation. Low and middle-income countries, which were already struggling to achieve progress towards the SDGs, are likely to suffer disproportionately. As a consequence, they will need to come up with policies that are affordable, achieve multiple SDGs simultaneously and can be implemented effectively and quickly. Three policies meet these criteria: a fossil fuel subsidy swap to fund clean energy investments and dissemination of renewable energy in rural areas; reallocating irrigation subsidies to improve water supply, sanitation and wastewater infrastructure; and a tropical carbon tax, which is a levy on fossil fuels that funds natural climate solutions. Through such interventions, developing countries can foster greater progress towards achieving the SDGs through cost-effective and innovative policy mechanisms that do not rely on external funding to implement. And, as their economies recover and poverty is reduced, these policies can become the basis of more sustainable development that delivers more widespread and inclusive growth.

If designed correctly, a 5 to 10-year strategy of investment and pricing reforms will not only green the post-pandemic recovery but also put the world economy on a more inclusive growth path, including generating net gains in employment, improving income and wealth distribution, and targeting gains towards vulnerable populations and poor countries. Combatting COVID-19 requires countries to work together towards a common goal. This goal should extend to cooperating on a common vision of global shared prosperity to the benefit of all humanity.

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