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**GREENING THE G7 ECONOMIES
THROUGH A MORE INCLUSIVE
CLIMATE CLUB**

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Abstract

Despite some progress, the Group of Seven (G7) have yet to act collectively to foster a low-carbon transition of their economies. This paper outlines such a strategy, which would also encourage other economies to follow suit. This strategy has three elements. First, the G7 should agree to end the underpricing of fossil fuels, including phasing out subsidies and phasing in taxes or tradable permits to cover the costs of local air pollution, global warming, and other damages. Second, any revenues saved or raised should be recycled to fund green innovation or additional measures to offset any adverse income or employment effects of a clean energy transition. Third, the G7 should require that fossil fuel pricing reforms are the main precondition for joining its proposed Climate Club and should impose a levy on carbon-intensive imports to encourage compliance by other countries. The G7 should also provide comprehensive assistance to emerging market and developing economies to help accelerate their clean energy transition, facilitate their eventual participation in the Climate Club, and foster the attainment of climate, poverty, and development goals that also promote strong and resilient economies.

Keywords: clean energy, carbon levy, climate club, fossil fuel pricing, green innovation, Joint Energy Transition Partnership, low-carbon transition, Partnership for Global Infrastructure and Investment

JEL Classification: Q54, Q58, F18, O44

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1. INTRODUCTION

The Group of Seven (G7) economies are at an important crossroads in fostering a low-carbon transition.¹ Accelerating human impacts on the biosphere have dramatically increased environmental risks worldwide, especially climate change (Barbier 2022a; IPCC 2022 and 2023). As a result, the IPCC (2023) has called for immediate and rapid cuts in global greenhouse gas emissions.

The G7 should be at the forefront of collective action to address this challenge. The G7 accounts for over half of global gross domestic product (constant 2015 US\$), 28% of carbon dioxide emissions from fossil fuels, and 13% of the world's population.² A low-carbon transition by G7 economies would have a significant impact on achieving global goals for net-zero emissions by 2050 and limiting warming to less than 2°C. Reducing fossil fuel use would also make these economies more sustainable, reduce reliance on energy from more authoritarian states, and promote a just transition to energy independence and security.

Yet, the G7 has struggled to green their economies. From 2020 to 2021, the G7 consistently implemented a higher proportion of “green” measures as part of their recovery and stimulus spending during the COVID-19 pandemic (Johnstone 2022). But green spending was a small share of overall expenditure during the pandemic (O’Callaghan et al. 2022). Large amounts of the stimulus supported greater production and use of fossil fuels and greenhouse gas emissions by the G7 (Dufour et al. 2021; Nahm, Miller, and Urpelainen 2022). In addition, the effectiveness of short-term green spending in fostering a low-carbon transition in G7 and other advanced economies is questionable, unless they are also committed to ending the underpricing of fossil fuels (Barbier 2020 and 2022a; Helm 2015; IEA 2021; IMF 2021; REN21 2022; Stern 2021).

Collective action by the G7 to foster a green transition is also facing difficulties. The 2022 Inflation Reduction Act (IRA) in the United States includes \$369 billion in clean energy and climate change investments that are likely to reduce substantially greenhouse gas emissions (Barbanell 2022). However, the IRA has also been accused of promoting “green protectionism” for giving generous tax credits to the US electrical vehicles and renewables industries, which has spurred retaliatory clean energy subsidies by the European Union and other G7 members (Lim et al. 2023; Rodgers, Pullins, and Dunham 2022). Equally, there is concern that implementation by the European Union of a carbon border adjustment mechanism (CBAM)—a tax on high-carbon imports, in order to equalize the cost of carbon between EU products and these imports—is likely to impose an increasingly heavy burden on trading partners, including other G7 countries, as its coverage expands to a broader range of goods and services, and the price of CBAM certificates escalates (Hufbauer et al. 2022). Efforts by the G7 to create an exclusive “Climate Club” have also been criticized as largely ineffective if it does not encourage and support participation by emerging market and developing economies and if it instigates “a giant CBAM by creating treaty-bound club goods and penalties” (Stern and Lankes 2022: 11).

Balancing these competing aims and objectives while meeting the climate change crisis should be a key priority for the G7.

¹ The seven members of the G7 are Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States. The European Union is also a member, although it does not host or chair summits.

² From the World Bank’s World Development Indicators. <https://databank.worldbank.org/source/world-development-indicators#> (accessed 18 January 2023).

This paper outlines a collective strategy for reducing overreliance on fossil fuels and promoting a transition to clean energy as well as encouraging other economies to follow suit. This strategy should have three elements that can be implemented immediately and at low additional cost:

- First, the G7 should agree to end the underpricing of fossil fuels, including phasing out subsidies and phasing in taxes or tradable permits to cover the costs of local air pollution, global warming, and other damages.
- Second, any revenues saved or raised should be recycled to fund green innovation or additional measures to offset any adverse income or employment effects of a clean energy transition and to invest in complementary infrastructure.
- Third, the G7 should use the adoption of fossil fuel pricing reforms as the main precondition for joining its proposed Climate Club, which should in turn adopt a levy on carbon-intensive imports and other incentives to encourage compliance by other countries.

In addition to these three elements, any strategy adopted by the G7 must include greater assistance for emerging market and developing economies (EMDEs) through the Joint Energy Transition Partnerships and Partnership for Global Infrastructure and Investment (PGII) to aid their low-carbon transition. This should be accompanied by offering support to EMDEs for adopting carbon pricing and other actions necessary for participating in the Climate Club and implementing novel and affordable policies that could achieve simultaneously poverty, development, and climate mitigation goals. The promotion of strong institutions and governance in EMDEs enables the establishment of resilient economies that are better equipped to deal with climate change as well as social unrest and conflict.

2. POLICIES FOR A GREEN TRANSITION

There are five key lessons from the 2008–9 Great Recession and the 2020–21 COVID-19 pandemic for designing a green transition strategy for the G7:

- The policies adopted by the G7 will have important implications not just domestically but also for the ***future greening of the world economy***.
- Although clean energy investment needs to increase dramatically, ***government spending alone is unlikely to lead to a low-carbon pathway***.
- ***Pricing reforms are also needed***, such as phasing out fossil fuel subsidies and phasing in carbon pricing and other environmental market-based incentives, to spur green investments and innovation, reduce fossil fuel dependency, and create a low-carbon economy.
- Any ***revenues raised or saved should be recycled*** to boost public sector support for green research and development (R&D), to offset any adverse income or employment effects of a clean energy transition, and/or to invest in other key infrastructure needs.

- **Collective action by the G7 is required** to foster policy coordination and effectiveness, and to encourage and help other economies to adopt similar policies.³

The extent and content of stimulus spending undertaken by the G7 economies during the COVID-19 pandemic illustrates its limitations in spurring a low-carbon transition. Although most of the world's \$20 trillion stimulus spending over 2020–21 was by the G7, only \$893 billion (4%) was on green recovery (O'Callaghan et al. 2022). Moreover, some of this spending was offset by support for fossil fuels and other polluting activities. Expenditure favoring fossil fuels was especially noticeable in early stimulus spending during the pandemic. Between January 2020 and March 2021, G7 governments allocated more than US\$189 billion to support coal, oil, and gas, while clean energy received only \$147 billion (Dufour et al. 2021). An analysis of all pandemic spending by the G7 over 2020–21 found that around \$729 billion may reduce greenhouse gas emissions but another \$82 billion could increase emissions (Nahm, Miller, and Urpelainen 2022).

The appendix of this paper highlights key green transition trends in G7 economies over the past three decades. Although there has been some progress, especially since 2000, the transition has slowed considerably in recent years.

Carbon dioxide (CO₂) emissions from fossil fuels and cement fell during the Great Recession (2008–9) and during the pandemic lockdown period (2020) but rose in the recovery years after these crises (see Figure A1). Consequently, since 2015, any improvements in per capita emissions and the emission intensity of economic output have been much less significant than in previous years (see Figures A2 and A3). And, as noted previously, the G7 still contributes around 28% of global CO₂ emissions from fossil fuels.

The growth in the renewable energy share of the total energy supply is considered essential for attaining net-zero carbon emissions by 2050, and any delay in progress over the coming years could make this target unattainable (IEA 2021; IPCC 2022). However, despite the falling cost of renewable use, in recent years the renewable share of energy in G7 economies has not grown as fast as anticipated (see Figure A4). In 2020, renewables still accounted for less than 20% of the total energy supply in the G7, ranging from a low of just under 7% in Japan to over 19% in Italy (see Figure A4). Consequently, the share of fossil fuels in the world's total energy mix is as high today as it was a decade ago. While renewables grew almost 5% per year from 2009 to 2019, fossil fuel shares remained at around 80% over the same period (REN21 2021). Meanwhile, fossil fuel subsidies in 2019 amounted to \$550 billion worldwide, which was almost double the total global investment in renewables in that year (REN21 2021). As a result, most of the increase in global energy demand since the pandemic has been from fossil fuels, contributing to the largest increase in global CO₂ emissions in history (REN21 2022).

Clearly, much more needs to be done to transform G7 economies and put them on a clean energy trajectory. The IEA (2021) estimates that clean energy investment would need to double by 2030 to keep global warming below 2°C and more than triple for a 1.5°C stabilization. The G7 may need to invest \$1 trillion per year from now until 2030 to accelerate the transition to a low-carbon economy and restore natural capital (Stern 2021). However, G7 governments are unlikely to provide the bulk of this investment,

³ These lessons are drawn from several policy reviews. See, for example, Agrawala, Dussaux, and Monti (2020); Barbier (2020, 2022a); Black et al. (2022); Hepburn et al. (2020); IEA (2021); IMF (2021); Jaeger et al. (2020); O'Callaghan et al. (2021).

given the sizable public debt incurred during the pandemic and the ongoing problem of global inflation. But the private sector is also showing reluctance to commit to investments on this scale. An important barometer of such a commitment is the willingness of the private sector to adopt emission-reduction targets to guide new investment. An analysis of greenhouse gas (GHG) emissions reduction targets publicly disclosed by over 4,600 companies in G7 economies shows that these targets are only ambitious enough to align with a 2.7°C decarbonization pathway (CDP 2022).

In sum, the additional investments and innovation necessary to achieve a green transition will only be forthcoming if G7 economies collectively act to address existing policy distortions and create the necessary market conditions and incentives. As the rest of the paper outlines, there are three key elements of such a strategy that can be implemented immediately and at low additional cost: ending the underpricing of fossil fuels; recycling revenues to finance public support for green innovation and other complementary policies; and designing and implementing an effective G7 Climate Club.

3. ENDING THE UNDERPRICING OF FOSSIL FUELS

Perhaps the most noteworthy market disincentive for a green transition is the persistent underpricing of fossil fuels. Such underpricing perpetuates dependency on fossil fuels, encourages excessive greenhouse gas emissions and other harmful pollutants, and discourages the technical innovation and adoption necessary to achieve a low-carbon economy. As explained by Helm (2015: 218):

“The reasons for this relative lack of basic technical progress are many and varied. Yet there is one overwhelmingly powerful factor: cheap fossil fuels have blunted the need for change...If the world is to address climate change, this continued relative price advantage for fossil fuels will have to be addressed by influencing the price through taxing or permitting carbon.”

The underpricing of fossil fuels occurs in two ways. First, the market prices for fossil fuels do not include the climate change damages from greenhouse gas emissions, air pollution that causes illness and deaths, or other social costs associated with using these fuels. Second, in many countries, exploration, production, and consumption subsidies artificially lower the price of fossil fuels in energy markets. The result is that current markets for coal, oil, and natural gas, as well as for their key products—electricity generation, diesel, and gasoline—not only exclude climate change damages and other environmental impacts, but in addition, the prices in these markets are frequently subsidized. 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. This substantially distorts the attractiveness of investing in and using these sources of energy compared to clean energy alternatives.

Parry, Black, and Vernon (2021) estimate the extent of underpricing of fossil fuels across economies. They include both direct *fossil fuel subsidies* (or explicit subsidies) and the *additional social costs of fossil fuels* (or implicit subsidies) that are unpriced. Fossil fuel subsidies are the undercharging of supply costs and producer subsidies. Additional social costs comprise any unpriced environmental damages, such as from local pollution, congestion, road accidents, and global warming, and the foregone consumption tax revenue due to this undercharging. Table 1 depicts the estimates by Parry, Black, and Vernon (2021) of the underpricing of fossil fuels for G7 economies in 2020.

Table 1: Underpricing of Fossil Fuels in G7, 2020

	Subsidies			Additional Social Costs	All Underpricing			Foregone Revenues		
	Total US\$ bn	% GDP	\$ per Capita	Total US\$ bn	Total US\$ bn	% GDP	\$ per Capita	Total US\$ bn	% GDP	\$ per capita
Canada	10.3	0.6%	272	53.7	64.0	4.0%	1,684	4.6	0.3%	120
France	1.7	0.1%	26	28.1	29.8	1.2%	441	9.6	0.4%	142
Germany	3.4	0.1%	41	68.3	71.7	2.1%	863	7.1	0.2%	85
Italy	2.9	0.2%	49	37.8	40.7	2.3%	685	21.5	1.2%	362
Japan	4.7	0.1%	38	164.8	169.5	3.9%	1,343	10.1	0.2%	80
United Kingdom	8.3	0.3%	124	15.3	23.6	0.8%	352	4.6	0.2%	68
United States	16.1	0.1%	48	646.0	662.1	3.4%	1,997	34.9	0.2%	105
Other EU	15.3	0.2%	64	122.2	137.5	2.2%	579	20.1	0.3%	87
Total G7	62.8	0.1%	62	1,136.2	1,199.0	2.8%	1,186	112.8	0.3%	112
World	454.8	0.6%	59	5,402.8	5,857.4	7.2%	755			
G7 share (%)	14%			21%	20%					

Other EU refers to all European Union countries other than France, Germany and Italy. G7 refers to all seven member countries plus Other EU. Subsidies are the undercharging of fossil fuel supply costs and producer subsidies (i.e., pre-tax subsidies). Parry, Black, and Vernon (2021) refer to these subsidies as the explicit subsidies for fossil fuels. Additional social costs of fossil fuels comprise any unpriced environmental damages, such as from local pollution, congestion, road accidents, and global warming (i.e., post-tax subsidies), and the foregone revenues from consumption taxes due to this undercharging (i.e., post-tax subsidies less pre-tax subsidies). Parry, Black and Vernon (2021) refer to these additional social costs as the implicit subsidies for fossil fuels. All underpricing of fossil fuels consists of the sum of subsidies and additional social costs.

Source: Parry, Black, and Vernon (2021) for fossil fuel underpricing estimates. Population and GDP (constant 2015 US\$) from World Bank World Development Indicators <https://databank.worldbank.org/source/world-development-indicators#>.

Fossil fuel subsidies in the G7 amount to \$63 billion per year, which is 0.1% of the aggregate GDP of these economies and averages out at \$62 per person. This comprises 14% of fossil fuel subsidies globally (\$455 billion). However, fossil fuel subsidies are only part of the cost to economies of underpricing. When the additional social costs of global warming, local pollution, congestion, road accidents, and lost revenue from underpricing are added in, the total costs of underpricing fossil fuels in the G7 are nearly \$1.2 trillion annually, 2.8% of GDP, and \$1,186 per person (see Table 1). Underpricing in the G7 comprises around 20% of the global total of \$5.9 trillion, but underpricing per person in the G7 is substantially higher than for the world average, which is \$755 per person.

The right-hand columns of Table 1 depict the foregone consumption tax revenues in G7 economies from underpricing fossil fuels. These amount to around \$113 billion per year, or around \$112 per person. The United States and Italy lose the most revenue from underpricing their fossil fuels. Canada and the United Kingdom pay out large amounts in subsidies to fossil fuels (\$10.3 and \$8.3 billion, respectively) but recoup some of these revenue losses through their carbon tax schemes and so their (net) foregone revenues are only \$4.6 billion each year.

The first step in reforming the underpricing of fossil fuels in G7 economies is the phasing out of any remaining consumption and production subsidies. One proposal is that the G7 should do this no later than 2025 (Stern 2021). Subsidy removal is urgently needed for a green transition to occur. For example, the International Energy Agency (IEA) argues that the persistence of fossil fuel subsidies in all economies, but especially in major economies such as the G7, is a major “roadblock” to their clean energy transition (IEA 2021). Such subsidies are considered the main deterrent to significant growth in the renewable share of total energy use and helped

spur the post-pandemic surge in fossil fuel consumption and greenhouse gas emissions (REN21 2022).

The second step of reform is for the G7 to improve its carbon pricing. In recent years, a number of G7 economies have employed carbon taxes, emission trading schemes (ETSs), or both instruments to help limit greenhouse gas (GHG) emissions and other environmental costs associated with fossil fuel use (see Table 2). However, Italy and the United States do not have any carbon pricing, although as an EU member Italy is part of its ETS. Japan's carbon tax is very low: only \$2 per tonne of carbon dioxide-equivalent (tCO_{2e}) emissions.

Perhaps the most ambitious carbon pricing approach has been the European Union Emissions Trading System (EU ETS). Introduced in 2005, it represents the central pillar of the EU climate change policy and the "European Green Deal." In 2021, further reforms were made to the EU ETS to help achieve the new EU-wide 2030 target of a 55% cut in GHG emissions compared to 1990 levels and the 2050 net-zero emissions goal. This included increasing the coverage of emissions, raising the price of traded emissions, and boosting revenues. The current price is \$87 per tCO_{2e} and annual revenues are around \$34 billion (see Table 2). Although no longer in the EU, the United Kingdom also introduced its own trading scheme that is compatible with the EU ETS.

Both carbon pricing and its coverage of GHG emissions must improve in the G7. To be on track for the 2050 net-zero emissions goal, high-income and large emitters, such as the G7, should as a bare minimum attain carbon pricing levels of \$75 per tCO_{2e} accompanied by other policies and regulations to reduce emissions (Black et al. 2022; Chateau, Jaumette, and Schwerhoff 2022; Parry, Black, and Roaf 2021). Postponing this step any longer could be detrimental to climate goals. Delaying action on carbon pricing by 10 years would likely result in missing the 2050 net-zero emission target by a large margin (IMF 2021).

Table 2: National Carbon Pricing Initiatives in G7, 2022

	Carbon Price (US\$/tCO _{2e})	Year Started	GHG Emissions Covered (MtCO _{2e})	Share of Country's GHG Emissions Covered	Annual Revenues (US\$ Mn)
Carbon Taxes					
Canada	40	2019	168	22%	4,798
France	49	2014	158	35%	9,632
Japan	2	2012	953	75%	1,800
United Kingdom	24	2013	97	21%	690
Emission Trading Schemes (ETS)					
Canada	40	2019	53	7%	264
European Union	87	2005	1,627	41%	34,326
Germany	33	2021	349	40%	7,940
United Kingdom	99	2021	130	28%	5,664

tCO_{2e} = tonnes of carbon dioxide equivalent. MtCO_{2e} = mega (10⁶) tonnes of carbon dioxide equivalent. GHG = greenhouse gas emissions. European Union ETS also includes Norway, Lichtenstein, and Iceland.

Source: World Bank, Carbon Pricing Dashboard https://carbonpricingdashboard.worldbank.org/map_data. Data last updated 1 April 2022.

Overall, there is growing evidence that carbon pricing is among the most effective policy tools for directing spending and investment out of dirty energy and into green alternatives, thus effectively reducing greenhouse gas emissions from fossil fuels. For example, a study of 142 countries over a period of two decades found that the average annual growth rate of CO₂ emissions from fuel combustion has been around 2 percentage points lower in countries that have had a carbon price than in countries without (Best, Burke, and Jotzo 2020).

Establishing and implementing a coordinated strategy to green the G7 economies is important to address the global challenge of climate change. In addition, to do so through collective action by the G7 economies enhances governance and institutions that promote strong and resilient economies. This is particularly important due to the increasing risk of climate change, as well as social conflict and unrest.

4. COMPLEMENTARY POLICIES AND INVESTMENTS

Ending the underpricing of fossil fuels in G7 economies would not only remove a major market disincentive to the clean energy transition but also raise substantial revenue for these economies. How G7 governments choose to spend these additional funds is also critical to spurring the transition to net-zero emissions and overcoming any adverse impacts on vulnerable populations, economic sectors, and regions.

Despite the overwhelming evidence of the harm from underpricing fossil fuels, many governments are generally resistant to ending subsidies and adopting carbon pricing. One of the obstacles is the widespread perception among some policymakers that doing so is “bad” for the economy.

This perception may be overstated. Economic studies of fossil fuel pricing reforms, including from taxing or permitting carbon, generally find little or no adverse impacts on GDP and overall employment (Goulder et al. 2019; Martin, de Preux, and Wagner 2014; Metcalf 2019; Metcalf and Stock 2020; Yamazaki 2017). For example, Metcalf and Stock (2020) examine the dynamic effect of carbon pricing on the growth rate of GDP and employment in 31 European Union countries—all members of the EU Emissions Trading Scheme. They do not find evidence that carbon pricing reduces GDP growth, and it positively impacts employment growth both immediately and for up to five years following implementation.

Nevertheless, there are other important concerns.

Many governments fear the loss of international competitiveness from fossil fuel pricing reforms, especially in high-emission sectors, such as steel, chemicals, and cement (Chateau, Jaumotte, and Schwerhoff 2022; de Gouvello, Finon, and Guigon 2019). However, there may be less of an overall impact on the competitiveness of G7 economies as they are less structurally dependent on high-emission industries. For example, in the European Union, the six industrial sectors that account for the most emissions are responsible for approximately only 2% of GDP and less than 1% of the total employment (de Gouvello, Finon, and Guigon 2019).

Policymakers are also wary of the political consequences of fossil fuel pricing reforms if they lead to sudden and sharp rises in energy prices and the gas, heating, and electricity costs borne by consumers. If implemented incorrectly and too abruptly, such reforms can be the catalyst for prolonged social unrest and civil strife. For example, the “Yellow Vest” protests in France began in November 2018 in opposition to proposed increases in carbon taxes, their effects on diesel prices, and the planned use of

revenues to fund public expenditures, but this has since led to widespread mistrust of government and dissatisfaction with carbon taxation (Douenne and Fabre 2022).

On the other hand, where fossil fuel pricing reform has been successfully implemented, transparency, information dissemination, and stakeholder consultation appear to be important for reducing the general distrust in government that may subvert such reforms (Douenne and Fabre 2022; Ewald, Sterner, and Sterner 2022; Klenert et al. 2018). For example, an information campaign launched to improve knowledge about climate change and climate policies, explain the role of carbon pricing, and consult with stakeholders could have averted the public distrust of carbon taxation that was a regrettable consequence of the Yellow Vest protests in France (Douenne and Fabre 2022). In comparison, the successful introduction in 1991 of the carbon tax in Sweden was accompanied by a general reform of the tax system to reduce other inequities and involved considerable stakeholder consultation (Douenne and Fabre 2022; Ewald, Sterner, and Sterner 2022).

These economic and political concerns can be addressed through **recycling revenues** from fossil fuel pricing reforms and **adopting complementary policies and investments**. For G7 economies, there are three spending priorities:

- **Boosting public sector support for green research and development (R&D)** leading to innovation.
- **Investing in other key green infrastructure needs**, such as clean energy and transport and nature-based solutions.
- **Offsetting any adverse income and employment effects** of a clean energy transition.

5. INCREASED PUBLIC SUPPORT FOR GREEN R&D

Underinvestment in green innovation is a major obstacle to the development of the low-carbon economy. Consequently, one important use in G7 economies of the revenues recycled from fossil fuel reforms is to address the lack of sufficient public sector support for green research and development (R&D) leading to innovation. These include R&D subsidies, public investments, protecting intellectual property, and other initiatives to spur more widespread clean energy innovation by businesses.

Long-term public support for clean energy R&D is necessary, because without it, the private sector will “underinvest” in such activities.

For example, long-term public support is required to provide an important impetus for rapid economy-wide innovation through “technology spillovers.” These occur when the inventions, designs, and technologies resulting from the R&D activities of one firm or industry spread relatively cheaply and quickly to other firms and industries. These include cross-firm externalities, industry-wide learning, skill development, and agglomeration effects. However, spillovers also undermine the incentives for a private firm or industry to invest in R&D activities. A private investor bears the full costs of financing R&D and may improve their 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, as public support wanes, private firms and industries routinely underinvest in R&D and there is less economy-wide innovation overall.

These challenges “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” (Rodrik 2014: 470). Such market disincentives have proven to be a significant deterrent to clean energy innovation and development in G7 economies. 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 a transition from fossil fuel dependency (Andres and Mealy 2021; Barbier 2020 and 2022a; Black et al. 2022; Fankhauser et al. 2013; IEA 2021; IMF 2021; Rodrik 2014).

Another benefit of increasing public R&D support for clean energy and other environmentally related technologies is that it helps reduce the costs of adoption of these innovations throughout the economy (Barbier 2020, 2022a; Black et al. 2022; IEA 2021; Gillingham and Stock 2018). Public expenditures targeted at clean energy R&D will lead to lower costs and wider adoption as the technology becomes more familiar, innovation spreads, and production scales up (Gillingham and Stock 2018). The result is lower economy-wide costs for adopting such technologies and a reduction in the costs of replacing fossil fuels with clean energy, leading to a more rapid fall in greenhouse gas emissions and a higher likelihood of attaining the 2050 net-zero goals (Black et al. 2022; IEA 2021; IMF 2021).

The appendix of this paper highlights two key public green R&D trends in G7 economies over the past three decades. Unfortunately, these trends suggest that additional public support for green R&D has not been forthcoming in these economies.

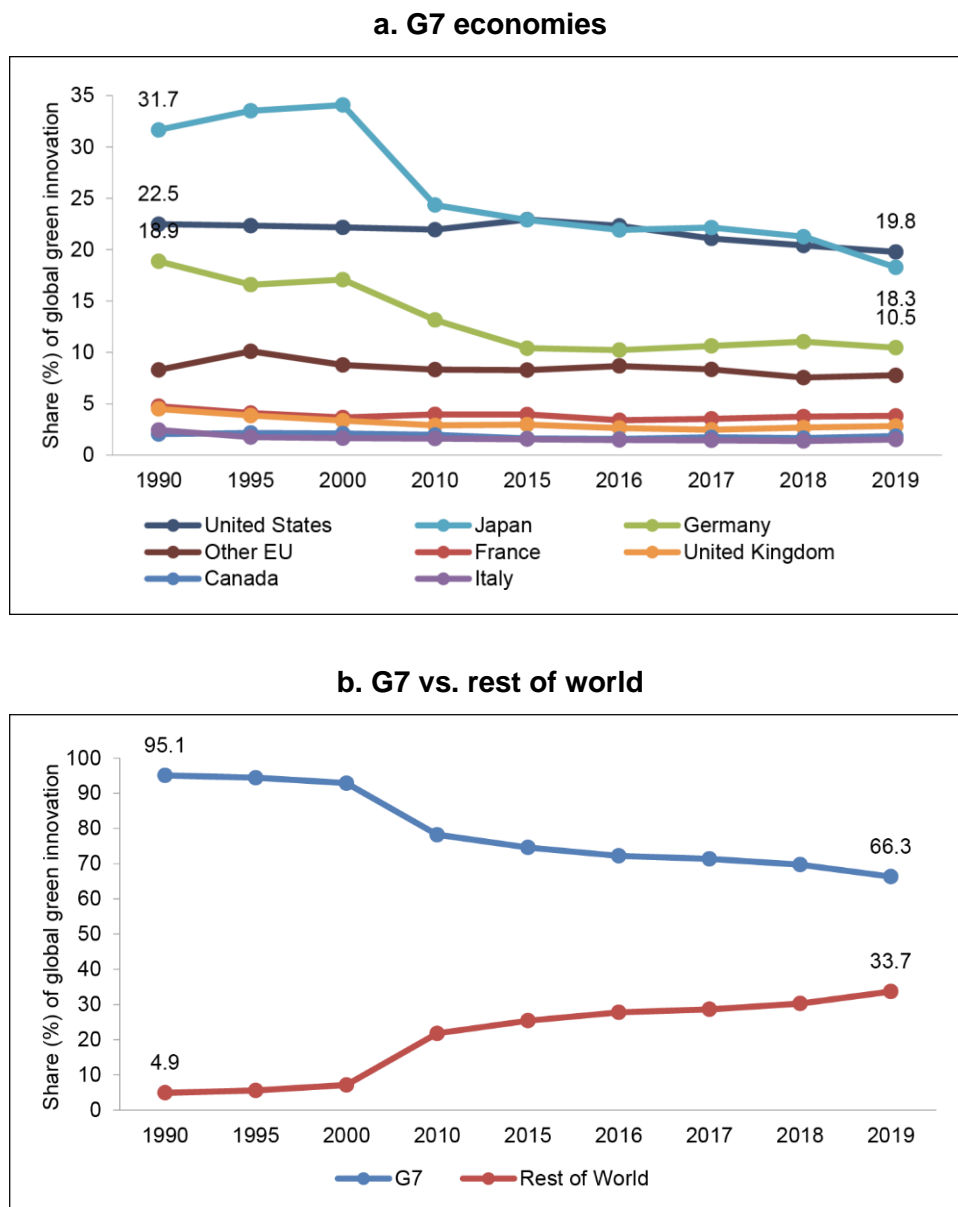
Although the renewable share of public support for total energy R&D rose sharply among G7 economies from the 1990s to the 2000s, since 2015 it has fallen in all economies and has stabilized at around 10%–20% of the total public R&D energy budget (see Figure A5). The share of environmentally related R&D in the total public R&D has also remained constant and at relatively low levels in the G7 (see Figure A6). For six of the economies, this share has hovered between 1.8% (United Kingdom and France) to around 3% (Germany), but in the United States it has been only 0.3%.

The lack of a substantial boost in public support for clean energy and other green R&D in the G7 is occurring just at a time when new technological developments are needed to drive the energy transition of the world economy. The result has been a drop-off in green innovation within the G7 as well as a diminishing contribution of these economies to global green technologies.

Within the G7, the development of environmentally related technologies as a share of total innovation has not increased in recent years, and in some economies, it has even fallen slightly (see Figure A7). The green share of total innovation ranges from just under 9% in the United States to just over 13% in Germany. Consequently, environmental innovations per capita have started to decline in G7 economies (see Figure A8).

The underinvestment in clean energy and other green innovations in G7 economies is important, as they have been the major source of these technological developments worldwide. But this contribution has fallen significantly in recent years (see Figure 1). In 1990, Japan, the US, and Germany provided almost three quarters of the green innovation worldwide, and the entire G7 was responsible for 95% of the global total. However, three decades later, the three economies account for less than 50% of environmentally related inventions worldwide, and the G7 just two thirds.

Figure 1: Share (%) of Environmentally Related Inventions Worldwide, 1990–2019



European Union is the average of the 28 member countries. G7 is the average of the seven member countries.
 Source: OECD (2023). Green growth indicators. OECD Environment Statistics Database. <https://doi.org/10.1787/data-00665-en>.

The decline in the G7’s contribution has not helped green innovation globally. In 2011, the share of environmentally related technologies in all inventions worldwide reached a peak of 13% but it then declined to 9.9% in 2019. Similarly, global green innovation reached six inventions per person in 2012 but fell to five inventions per capita in 2019.⁴

In sum, more public investment to support clean energy and other environmental innovations will require additional funding by all G7 governments. As an example, G7 economies should look to the recent strategy adopted by their fellow G20 member the

⁴ From OECD (2023). Green growth indicators. OECD Environment Statistics Database. <https://doi.org/10.1787/data-00665-en>.

Republic of Korea, which has actively pursued policies to support green innovation through expanded government support since the 2008–9 Great Recession. From 2010 onwards, the Republic of Korea increased its share of government R&D devoted to environmental technologies by over 50%, which is now reaching the levels of Germany, which has the highest share (ca. 3%) among G7 economies. Over the period 2010–2019, the Republic of Korea also devoted over a quarter of its annual public support for energy R&D to renewable development, which is higher than any G7 economy. As a result, the Republic of Korea's share of global green innovation increased from 3% in 2000 to 12.0% in 2019, and it is now producing nearly 90 environmentally related inventions per person. Among the public programs that support green R&D in the Republic of Korea are tax credits and allowances, tax reductions for the wages of R&D workers, and accelerated depreciation of capital used for R&D. Together, these public programs amount to 0.3% of GDP, which is one of the highest levels of support among major economies, including the G7.⁵

6. ADDITIONAL PRIORITIES

Recycling revenues from fossil fuel pricing reforms should also be targeted to help fund other important complementary policies and public investments for the green transition.

Additional public support and investments may be critical for overcoming key bottlenecks to rapid green structural transformation of G7 economies (Barbier 2020, 2022a). One obstacle is inadequate transmission infrastructure for renewables. This can only be addressed through public investments to design and construct a “smart” electrical grid transmission system that can integrate diffuse and conventional sources of supply. Government support may also be necessary to develop regional and national networks of charging stations to facilitate the rapid adoption of electrical vehicles. For example, purchases of electric vehicles will stimulate the demand for charging stations, which once installed will reduce the costs of running electric vehicles and further boost demand (Gillingham and Stock 2018). Another priority is improved urban development through combining municipal planning and transport policies for more sustainable cities. Finally, public investment in mass transit systems, both within urban areas and on major routes connecting cities, has been a long-neglected aspect of public infrastructure development.

Public policies and investments to support *nature-based solutions* are also important. These are broadly defined as actions to conserve, sustainably manage, and restore natural or modified ecosystems, which also enhance their ability to retain or absorb more carbon. Through restoring landscapes, halting land use change, increasing soil carbon levels, and enhancing wetlands and other ecosystems, nature-based solutions (NBSs) are increasingly considered cost-effective investments for mitigating greenhouse gas emissions from land use in temperate G7 regions (Barbier 2020 and 2022a; EASAC 2019; Fargione et al. 2018; Griscom et al. 2017). For example, the United States could abate 299 million tonnes CO₂e of greenhouse gas emissions annually through NBSs, which would also provide other benefits, such as air and water filtration, flood control, and conservation of soil and wildlife habitats (Fargione et al. 2018). For Europe as well, afforestation, reforestation, and other nature-based solutions have been found to be “the least costly and most easily deployable existing” carbon dioxide removal investments (EASAC 2019: 4).

⁵ These data are from the OECD's “Green growth indicators,” OECD Environment Statistics <https://doi.org/10.1787/data-00665-en>. For more discussion on the Korean government's strategy, see Barbier (2020).

In 2023, the United Kingdom launched its Environment Improvement Plan, which is the first installment of a 25-year plan for restoring and conserving nature (HM Government 2023). The overall aim is for between 65% and 80% of landowners and farmers to adopt nature-friendly farming on at least 10%–15% of their land by 2030, including the adoption of nature-based solutions to restore or create more than 500,000 hectares of wildlife-rich habitat outside of protected areas by 2042. These activities will be funded largely by the Sustainable Farming Incentive (SFI), which will be financed through reallocating farm subsidies to pay farmers instead for protecting nature and improving the environment. The SFI could prove to be an effective model for other G7 economies to adopt to promote more sustainable agriculture and spur NBS investments by landowners.

Another important use of the revenues recycled from fossil fuel reforms is to offset any adverse income or employment effects of a clean energy transition. The complementary policies adopted for this goal can be designed as part of the pricing reforms. For example, the Canadian province of British Columbia designed its carbon tax to be revenue-neutral, using any funds raised to reduce corporate and personal income taxes and target income and tax credits to low-income households (Metcalf 2019; Yamazaki 2017).

Other possible options include recycling revenues to lower payroll taxes, paying annual dividends to households, raising the minimum wage, providing payments or retraining for displaced workers, and reducing burdens for vulnerable households affected by the green transition (Barbier 2020, 2022a; Klenert et al. 2018). One approach would be to hire displaced workers from the fossil fuel industry to plug abandoned and orphaned oil and gas wells, which would also reduce GHG emissions. During the pandemic, Canada carried out a \$1.7 billion scheme for such a program as part of its recovery spending (Raimi, Nerurkar, and Bordoff 2020).

Using the revenues from carbon pricing to fund dividend schemes and tax rebates is often advocated as a means for addressing equity concerns and even public opposition to carbon taxation (Klenert et al. 2018; Mildemberger et al. 2022). So far, only two countries, Canada and Switzerland, have adopted such policies. In Canada, the federal government imposed a carbon tax and rebate scheme for households in 2019 in four provinces that contain half of the country's population. The policy is considered highly progressive, with 80% of households receiving more in dividends than they pay in carbon taxes. Switzerland established its carbon tax and rebate scheme in 2008, with two thirds of revenue recycled to businesses and the public. Each individual, including children, receives a rebate, through a discount of household health insurance premiums. However, surveys of both countries found only weak public support for the policy, with respondents often unaware of the rebate benefits they were receiving while their opinions were often shaped by partisan politics (Mildemberger et al. 2022).

In addition, redistributing revenues through economy-wide dividend schemes may be less effective and cost-efficient than more targeted approaches aimed at more vulnerable and low-income households (Ari et al. 2022; Goulder et al. 2019). Evidence from Europe of the energy price surge after the Russian invasion of Ukraine suggests that the most effective and efficient policies provide vulnerable households with income support without distorting the marginal price they pay for energy (Ari et al. 2022). In the United States, inflation-indexed transfers targeted at households in the lowest income quintile avoid what otherwise would be regressive overall impacts of any carbon tax by providing additional nominal transfers to compensate for the higher overall consumer prices induced by the tax (Goulder et al. 2019).

Finally, the pricing reforms can also be designed to address other key economic concerns. For example, conditional tax exemptions, tax differentiation, and compensation measures can be used to address competitiveness concerns. One option is to make carbon tax exemption contingent on meeting certain mitigation objectives, such as a commitment to implementing energy conservation measures, as done in the UK's Climate Change Agreement (CCA) and Climate Change Levy (CCL) mechanism (de Gouvello, Finon, and Guigon 2019).

7. G7 CLIMATE CLUB

At its 2022 summit in Germany, the G7 agreed to form a Climate Club Task Force with the expectation of a full launch in 2023 to coincide with COP28. According to the G7, “the Climate Club’s initial scope will be on unlocking the potential for the decarbonization of hard-to-abate industrial sectors” (G7 2022: 1). Its overall purpose is to support the implementation of the Paris Agreement, including the 2050 net-zero carbon emission goal, by accelerating climate action while addressing the risks of *carbon leakage* (Böhringer et al. 2022; Sartor et al. 2022; Stern and Lanke 2022).⁶

As outlined by Nordhaus (2015), the main objective of any climate club is to overcome *free-riding* in international climate policy.⁷ To do so effectively, the club must contain two policy mechanisms. First, to achieve harmonized emissions reductions, countries participating in the club must agree on an *international target carbon price*. Second, once formed, the climate club should *impose penalties on nonparticipating countries*.

Any G7 Climate Club should strive to create these two policy mechanisms. In addition, the club must support the main policy actions at the core of the green transition strategy for the G7, while at the same time providing incentives for other countries, including emerging market and developing economies (EMDEs), to join the club. These objectives can be achieved in the following manner.

First, the G7 should stipulate that ***the adoption of fossil fuel pricing reforms is the main precondition for joining*** its proposed Climate Club. To form the Club initially, all G7 members should agree to begin phasing out fossil fuel subsidies and develop a schedule for phasing in carbon pricing. Other countries wishing to join the Club should also agree to such policies as preconditions.

Countries such as the United States that have opted for regulatory approaches or subnational carbon pricing incentives, as opposed to national carbon taxes or emissions trading schemes, should be allowed to have these alternative policy mechanisms count as part of their overall efforts to reduce greenhouse gas emissions

⁶ *Carbon leakage* occurs if, in response to the implementation of additional climate policies, carbon-intensive production is displaced to countries that do not impose the policies. Carbon leakage has potentially two effects. Less overall reduction in greenhouse gas emissions occurs from implementing the climate policies, and the producers in countries with stricter policies may lose international competitiveness. As pointed out by Sato and Burke (2021), the latter “leakage concerns arise when one country decides, ahead of others, to implement ambitious policies to encourage industries to transition to carbon-neutral production. Compliance costs are either passed through to consumers or absorbed by the regulated companies, raising the possibility of being undercut by imports that have not paid equivalent carbon prices, leading to leakage.”

⁷ As explained by Nordhaus (2015: 1339), “*Free-riding* occurs when a party receives the benefits of a public good without contributing to the costs. In the case of the international climate-change policy, countries have an incentive to rely on the emissions reductions of others without taking proportionate domestic abatement. To this is added temporal free-riding when the present generation benefits from enjoying the consumption benefits of high carbon emissions, while future generations pay for those emissions in lower consumption or a degraded environment.”

through establishing an equivalent price on carbon.⁸ In the absence of a functional national policy response, it has been shown that sufficient subnational agreements—e.g., at the state, province, or regional level—can generate significant abatement on a par with national commitments (Iverson, Burgess, and Barbier 2020; Peng et al. 2021). For example, in the United States, state, city, and business commitments and actions could reduce emissions by 25% below 2005 levels by 2030, and enhancing actions by these actors could reduce US emissions by up to 37% (Hultman et al. 2020).

Second, the G7 Climate Club should agree to implement policies that would **establish a carbon price floor** among all members, ideally by 2030, if not sooner. The price floor should be differentiated—lower for emerging market and developing economies that join the Club and higher for advanced economies, such as the G7 and other high-income countries. Participants in the Club should be allowed flexibility in achieving the price floor through either carbon pricing or the equivalent nonpricing policies (e.g., regulations and subnational commitments). Initially, the carbon price floor should be established for power generation and heavy industry, such as cement, steel, and chemicals, and progressively extended to other sectors and sources of emissions.

Limiting the initial arrangement of the Climate Club to a core group of high-emitting countries, such as the G7 economies, would facilitate agreement on a common price floor for all participants, which would be much easier to negotiate and implement than a separate emissions target for each participant (Parry, Black, and Roaf 2021). This would especially be the case given that members could have the flexibility to set high prices above the minimum price floor to achieve more ambitious mitigation pledges and to use emissions-equivalent nonpricing policies to meet the price floor requirements.

To encourage other countries to join the G7 Climate Club, **the carbon price floor should be differentiated**. Researchers at the International Monetary Fund (IMF) have recommended a 2030 price floor of \$75 per tonne of carbon for high-income countries, \$50 per tonne for middle-income economies, and \$25 per tonne for low-income countries (Black et al. 2022; Chateau, Jaumotte, and Schwerhoff 2022; Parry, Black, and Roaf 2021). Such a differentiated price floor is also more progressive in terms of emissions reductions among Club members, as it will induce proportionally more carbon mitigation by high-income countries (Chateau, Jaumotte, and Schwerhoff 2022).

Initially, the price floor could be established for *emission-intensive and trade-exposed* (EITE) industries (Black et al. 2022; Chateau, Jaumotte, and Schwerhoff 2022; Parry, Black, and Roaf 2021). EITEs are core industries, primarily manufacturing, that release large amounts of greenhouse gas emissions and face significant national or global competition for their products. They include heavy industries, such as cement, chemicals, and iron and steel.⁹ For example, the International Energy Agency (IEA 2022) has called for urgent policy action by the G7, as it produces 17% of the world's steel, 8% of cement, and 28% of primary chemicals, and CO₂ emissions from these G7

⁸ An important step in including regulatory and other nonpricing policies is to develop methodologies to estimate the *implicit price* associated with these policies, i.e., the equivalent price per ton of carbon arising from the adoption of nonpricing policies to reduce greenhouse gas emissions (Stern and Lankes 2022). The Inclusive Forum on Carbon Mitigation Approaches (IFCMA) established by the OECD (2022) has begun assessing price-based and nonpricing mitigation policies and the impact of different policy approaches on greenhouse gas emissions across member countries, which is an important step in estimating the implicit price of nonpricing policies.

⁹ Globally, energy use in industry accounts for 24.2% of greenhouse gas emissions, with the largest contribution coming from iron and steel (7.2%) and chemical and petrochemicals (3.6%). Direct industrial processes account for an additional 5.2% of global emissions, with cement producing 3% (see Ritchie, Roser, and Rosado (2020)).

industries must decline by 27% by 2030 if the global net-zero target is to be achieved by 2050.¹⁰

Third, to incentivize more nonparticipants to join, to minimize competitiveness losses of its exposed EITE sectors, and to reduce carbon leakage, the G7 Climate Club will need to **impose a carbon import levy**. This is a charge on the carbon embodied in imports from regions without carbon pricing that is equivalent to the Club's differentiated minimum pricing floor levels of \$75 per tonne of carbon for high-income countries, \$50 per tonne for middle-income economies, and \$25 per tonne for low-income countries. Such a border carbon adjustment is necessary to protect the competitiveness of EITE industries of G7 Climate Club participants as well as to safeguard their willingness to pursue collective policy actions (Böhringer et al. 2022; Chateau, Jaumotte, and Schwerhoff 2022; Hagen and Schneider 2021; Tagliapietra and Wolff 2021).

The combination of a carbon price floor along with an import levy for EITE sectors could be an effective initial policy for the G7 Climate Club. For example, modeling simulations by Chateau, Jaumotte, and Schwerhoff (2022) demonstrate that such a policy combination would allow the economies within the agreement to implement ambitious mitigation policies without concern for carbon leakage and loss of competitiveness to their EITE industries. In the short term, the import levy would induce emerging market and developing economies to impose a carbon price on their EITE sectors, rather than being exposed to a border carbon adjustment. In the longer term, a differentiated carbon price floor with lower minimum levels for low- and middle-income countries would encourage their participation in the Climate Club.

8. ASSISTANCE FOR EMERGING MARKET AND DEVELOPING ECONOMIES

As part of its collective strategy, the G7 should also consider how best to encourage greater climate change mitigation and adaptation in emerging market and developing economies (EMDEs). Such assistance should also help EMDEs adopt the necessary policies and infrastructure investments to participate in the G7 Climate Club. The ultimate aim should be for EMDEs to eventually pursue the same strategy as the G7, but they should proceed cautiously with some policies, such as implementing fossil fuel pricing reforms, and they may need to pursue additional actions compatible with their development and poverty objectives.

To achieve these goals, the G7 should direct assistance toward EMDEs in three key areas:

- **Scale up and broaden recent G7 initiatives**, such as the Just Energy Transition Partnerships and the Partnership for Global Infrastructure and Investment, to accelerate the clean energy transition in EMDE partners.

¹⁰ An additional benefit of creating a carbon price floor for EITE industries is that it would facilitate the use of industry-friendly policy instruments, such as *carbon contracts for differences* (CCfD). A CCfD is a contract between a government entity and a private company that sets a fixed carbon price over a given period. Such CCfDs are considered important for encouraging rapid mitigation of greenhouse gas emissions by manufacturing, and especially EITE, industries, as the contracts reduce the investment risk for companies and share the costs of abatement between public and private entities (Gerres and Linares 2020; IEA 2022). With a carbon price floor in place, this minimum price would be the basis for the fixed price for CCfDs, further reducing the long-term risk of abatement investments undertaken by the EITE sector.

- **Assist EMDEs in establishing the minimum carbon price floor** requirements of the G7 Climate Club through carbon pricing and other policies.
- **Encourage EMDEs to develop novel and affordable policies** that could achieve simultaneously poverty, development, and climate mitigation goals, especially in rural areas.

The Just Energy Transition Partnership (JETP) is a recently launched financing cooperation mechanism created by the G7 to help EMDEs reduce fossil fuel dependency, and especially overreliance on coal, to accelerate a clean energy transition. The first JETP was established between G7 members and South Africa at COP26 in Glasgow in 2021, two new partnerships were launched with Indonesia and Viet Nam in 2022, and two more are planned with Senegal and India.

If expanded and adequately funded, JETPs could accelerate the clean energy transition in EMDE partners and encourage their eventual participation in the G7 Climate Club. This would require scaling up and broadening the assistance provided by the G7 while working with its partners to implement the carbon pricing and other actions necessary for them to join the Climate Club.

The JETPs are an important initial step in reducing fossil fuel use and carbon emissions in partner EMDEs, but more financial assistance and investments will be needed to foster the low-carbon transition in these countries. The JETP with South Africa promises \$8.5 billion for developing renewable energy, Indonesia is to receive \$20 billion to shut down some of its coal plants and bring forward peak carbon emissions by seven years to 2030, and Viet Nam will receive \$15.5 billion over the next 3–5 years to reduce its peak coal capacity and source 47% of its power from renewable energy by 2030.¹¹ However, the sums needed for a clean energy transition in these economies are much larger. For example, in its JETP Implementation Plan, South Africa estimates that the additional finance it needs for renewable energy, electrical vehicles, and green hydrogen is \$98 billion, and not the \$8.5 billion pledged by the G7 (Kramer 2022). Indonesia could reach its 31% renewable energy goal by 2050, but it would need an additional \$16 billion to do so (IRENA 2017).

The G7 could also support JETPs and the clean energy transition in partner countries through its other new initiative, the Partnership for Global Infrastructure and Investment (PGII). Launched at the 2022 G7 summit in Germany, the PGII seeks to mobilize \$600 billion in global infrastructure investments from public and private sources by 2027, with \$200 billion pledged by the United States already (White House 2022). A major aim of the initiative is “to close the infrastructure gap in developing countries.” The G7 maintains that the PGII will prioritize supporting projects that address climate change, and green and sustainable infrastructure, reduce pollution, and increase energy efficiency, although the majority of projects under the initiative so far are for digital technology, health, and conventional infrastructure investments (Moses and Zhu 2022).

To help accelerate the low-carbon transition in partner EMDEs, the PGII should prioritize green infrastructure investments that are complementary to the financing of this transition through JETPs. As highlighted earlier in this paper, there are several key infrastructure investments that are critical for accelerating clean energy adoption and use in any economy. These investments should be a priority for the PGII if this initiative is to **close the green infrastructure gap in EMDEs**. They include:

¹¹ As reported by Guarascio, F. G7 nations to provide Viet Nam with \$15.5 bln to cut coal use. *Reuters*, 14 December 2022. <https://www.reuters.com/business/energy/g7-vietnam-reach-155-bln-climate-deal-cut-coal-use-sources-2022-12-14/>

- Developing a “smart” electrical grid transmission system that can integrate diffuse and conventional sources of supply.
- Developing regional and national networks of charging stations to facilitate the rapid adoption of electrical vehicles.
- Improving urban development through combining municipal planning and transport policies for more sustainable cities.
- Investing in mass transit systems, both within urban areas and on major routes connecting cities.
- Adopting and developing new low-carbon technologies, such as green hydrogen, that may assist low-carbon industrial transformation.
- Targeting decarbonization of emission-intensive and trade-exposed (EITE) industries.

In exchange for greater financial and infrastructure investments to accelerate their clean energy transition, partner EMDEs should commit to adopting the appropriate carbon pricing and other policies necessary to attain the minimum carbon price floor requirements for participating in the G7 Climate Club. The G7 should assist potential EMDE members with these policy efforts.

The G7 could provide this assistance through collaboration with the Partnership for Market Implementation Facility (PMIF).¹² Following the successful Partnership for Market Readiness (PMR), which since 2011 has helped 23 countries establish the necessary building blocks to implement carbon pricing, the World Bank launched the PMIF in 2021 with the goal of putting carbon pricing policies and programs in place in at least 30 countries by 2025. Three of the countries currently assisted by the PMIF are Indonesia, Senegal, and Viet Nam, which already have JETPs with the G7, and Canada, the European Commission, Germany, Japan, and the United Kingdom are among the donors behind the initial \$125 million funding of the PMIF.

Consequently, the G7 could support and expand the PMIF by providing additional capitalization so that the scheme can help more EMDEs to adopt carbon pricing. One important objective would be to help these countries overcome the “dime” problem—design, implementation, monitoring, and enforcement—which is a key barrier to market-based instruments. The priority for PMIF assistance should be those EMDEs that are willing to:

- form Just Energy Transition Partnerships with the G7,
- engage in complementary green infrastructure investments through the PGII, and
- seek PMIF assistance to adopt carbon pricing and other actions necessary for them to join the G7 Climate Club.

EMDEs may also need assistance to develop novel and affordable policies that could achieve simultaneously poverty, development, and climate mitigation goals, especially in rural areas. Two policies appear to meet these criteria:

- **a fossil fuel subsidy swap** to fund clean energy investments and dissemination of renewable energy in rural areas, and
- using proceeds from a **carbon tax to fund nature-based solutions**.

¹² Details on the Partnership for Market Information Facility (PMIF) can be found at <https://pmiclimate.org/> including the latest annual report (PMIF 2022).

Ending the underpricing of fossil fuels in EMDEs must occur through policies that are compatible with achieving immediate development objectives, such as ending poverty and especially the widespread “energy poverty” in rural areas. A proven strategy that could be implemented relatively easily in EMDEs is a “subsidy swap” for fossil fuels, whereby the savings from a partial and limited reform for coal, oil, and natural gas consumption subsidies are allocated to fund clean energy investments (Barbier 2022a, 2022b; Bridle et al. 2019; Sanchez, Wooders, and Bechauf 2020). For example, 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 (Bridle et al. 2019). A study of 26 countries, 22 of which are EMDEs, finds that such a policy could substantially reduce greenhouse gas emissions by 2030 (GSI 2019).

A fossil fuel subsidy swap could also be used to facilitate greater dissemination and adoption of renewable energy and improved energy efficiency technologies in rural areas, which has been done through a number of different programs in EMDEs worldwide (Barbier 2022a, 2022b; Pahle, Pachauri, and Steinbacher 2016; Zaman, van Vliet, and Posch 2021). One possibility is the expansion of solar energy “safety nets” aimed especially at the millions of poor rural households that live in remote areas and are still without access to energy (Barbier 2022b; Zaman, van Vliet, and Posch 2021). These are targeted social assistance programs to provide solar power as an off-grid solution to solving the lack of access to energy for poor rural households in remote locations. Off-grid solar energy not only improves livelihoods and welfare but could also improve the resilience of the rural poor to adverse environmental and economic shocks, including the ongoing COVID-19 pandemic and similar outbreaks. Both Bangladesh and India have piloted such schemes, which provide clean energy access to remote rural households through free distribution of solar home systems and solar lamps (Zaman, van Vliet, and Posch 2021).

As discussed previously, *nature-based solutions* (NBSs) have been proposed as a way of preventing further losses in biodiversity while curbing greenhouse gas emissions from tropical land use change. NBSs are conservation, restoration, and improved land management actions that protect biodiversity and ecosystem services while simultaneously reducing greenhouse gas emissions (Griscom et al. 2017). NBSs are relatively inexpensive in the tropics. For example, cost-effective tropical NBSs can mitigate 6,560 10^6 tonnes of CO₂e in the coming decades at less than \$100 per 10^3 tonnes of CO₂e, which is about a quarter of emissions from all tropical countries (Griscom et al. 2020).

Although increasing investments in nature-based solutions in EMDEs may be an important and immediate spending priority, a key issue for many fiscally constrained economies could still be how to fund them. Even before the COVID-19 pandemic, the international community provided insufficient financing of such investments in tropical countries (Griscom et al. 2020; Barbier 2022a). Only 3% of climate mitigation funding is allocated to controlling global land degradation and loss (CPI 2019). One novel approach, which has been adopted in Costa Rica since 1997 and was used by Colombia in 2016, is to place a small carbon levy on fossil fuel imports and consumption, with some of the proceeds allocated to increasing investments in nature-based solutions (Barbier et al. 2020).

For example, Colombia’s policy amounts to an effective carbon tax of \$5 per tCO₂ on all fossil fuels. It yielded revenues of \$148 million in 2017 and \$91 million in 2018, of which 25% is used to manage coastal erosion, reduce and monitor deforestation, conserve water sources, protect strategic ecosystems, and combat climate change. A further 5% of the revenues is allocated to strengthen Colombia’s national system of

protected areas. In Costa Rica, the policy also funds a payment for ecosystem services scheme targeted at districts with high levels of poverty, and it assists smallholder farmers and indigenous peoples in submitting requests for funds. Around 40% of beneficiaries in Costa Rica are communities that live below the poverty line (Barbier et al. 2020). Such a strategy can have a significant impact on disadvantaged communities. Ecosystem services such as drinking-water supply, food provision, and cultural services contribute almost 30% of the income of households who live in forests, and even a larger share for the poor (Angelsen et al. 2014). Such services can make an important contribution to ending extreme poverty, alleviating hunger, improving health, and putting EMDEs on a more solid and resilient path towards sustainable development.

9. SUMMARY AND CONCLUSION

This paper has outlined a policy strategy for the G7 that reduces overreliance on fossil fuels, promotes a transition to clean energy, and encourages other major and smaller economies to follow suit. Figure 2 provides a summary of the overall strategy.

At the core of the strategy are the three policy elements that the G7 should adopt as soon as possible. These elements are:

- ***Phasing out any remaining consumption and production fossil fuel subsidies.***
- ***Phasing in improved carbon pricing and other policy actions.***
- ***Recycling revenues to public support for green R&D, key green infrastructure investments, and offsetting adverse income and employment effects.***

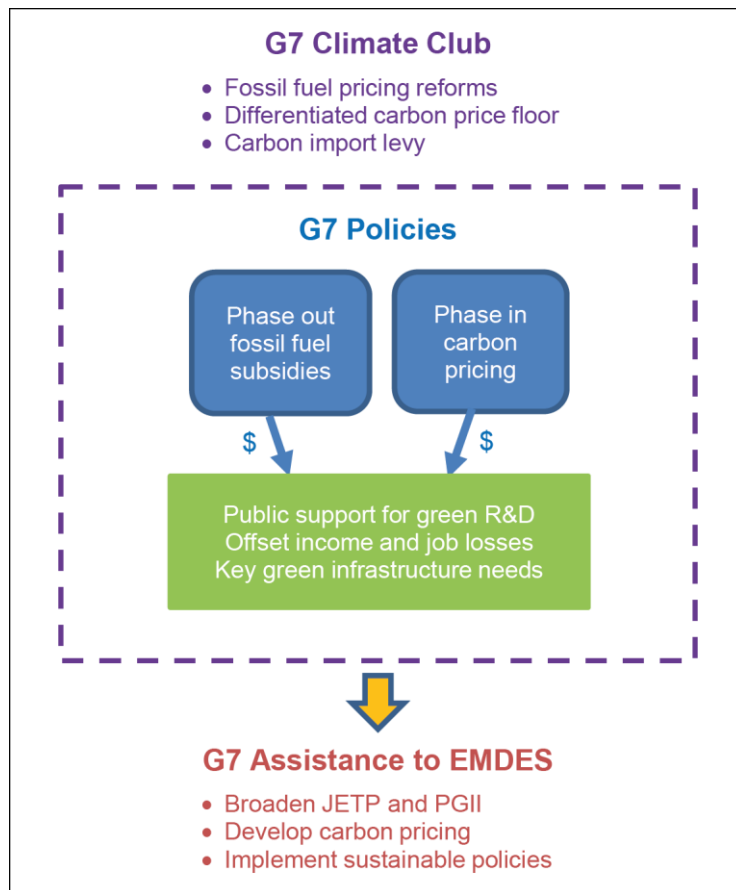
To support this policy agenda, and to further accelerate global climate action towards the 2050 net-zero goal, the G7 should develop and expand its proposed Climate Club. These objectives can be achieved if the Club adopts:

- ***Fossil fuel pricing reforms as the main precondition for joining.***
- ***A differentiated carbon price floor***, which is lower for EMDEs than for high-income members.
- ***A carbon import levy***, to support the policies adopted by the Club and to encourage more countries to join.

Finally, the G7 should target assistance to EMDEs that can help them reduce their overreliance on fossil fuels and promote a transition to clean energy as well as adopting the necessary policies and infrastructure investments to participate in the Climate Club. Three types of assistance are required:

- ***Scale up and broaden recent G7 initiatives***, such as the Just Energy Transition Partnerships and the Partnership for Global Infrastructure and Investment, to accelerate the clean energy transition in EMDE partners.
- ***Assist EMDEs in establishing the minimum carbon price floor*** requirements of the G7 Climate Club through carbon pricing and other policies.
- ***Encourage EMDEs to develop novel and affordable policies*** that could achieve simultaneously poverty, development, and climate mitigation goals, especially in rural areas.

Figure 2: G7 Green Transition Strategy



By adopting such a comprehensive and coherent strategy, the G7 can not only act collectively to accelerate a low-carbon transition of their economies but also encourage other countries to follow suit. The overall aim of this strategy is to create the conditions for an inclusive Climate Club, which encourages more countries, including EMDEs, to create the market and institutional conditions for a clean energy transition, foster the attainment of climate, poverty, and development goals, and promote strong and resilient economies.

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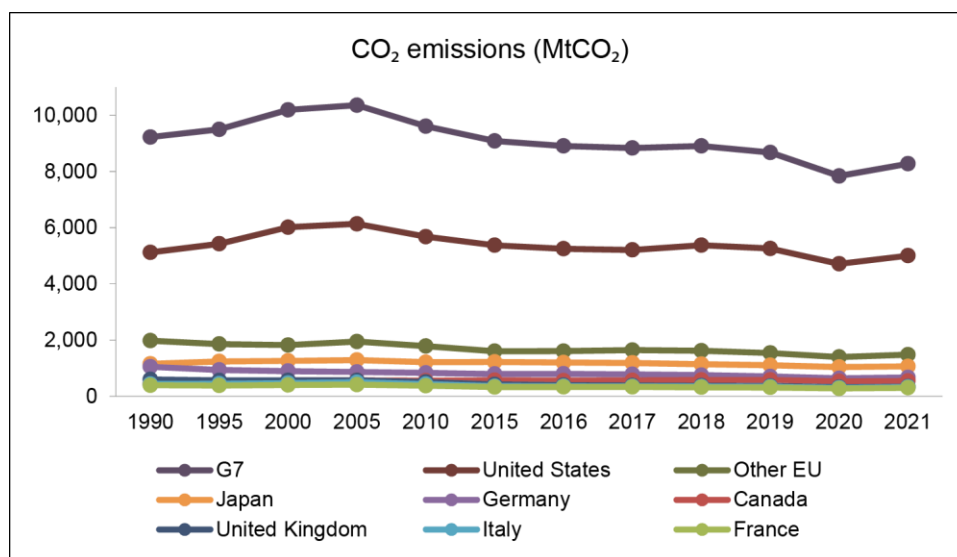
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APPENDIX: SELECTIVE GREEN TRANSITION TRENDS IN THE G7

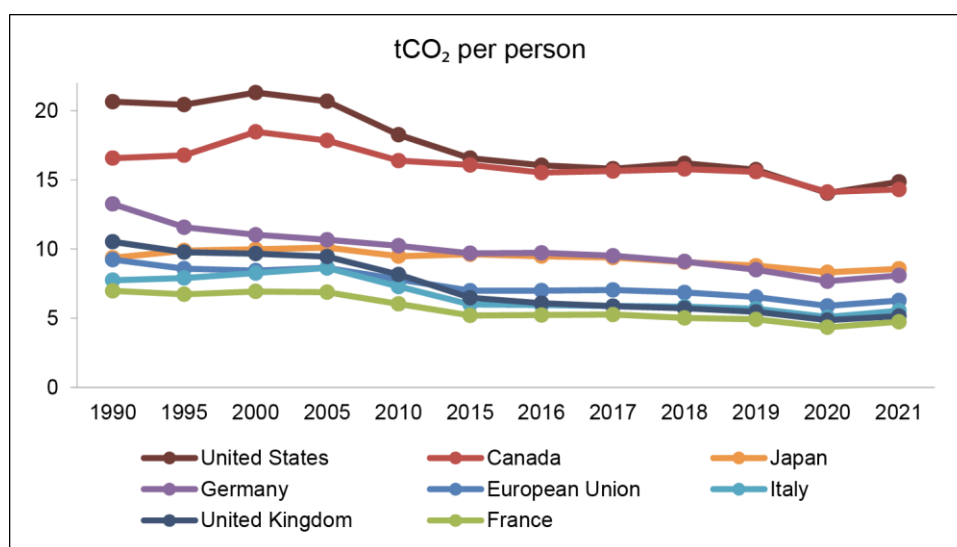
Figure A1: Carbon Dioxide Emissions from Fossil Fuels and Cement (MtCO₂), 1990–2021



Carbon dioxide emissions from the use of coal, oil, and gas (combustion and industrial processes), the process of gas flaring, and the manufacture of cement. Other EU is the total emissions of other European Union countries, excluding France, Germany, Italy, and the United Kingdom. G7 is the total of the seven member countries plus Other EU. Mt = mega (10⁶) metric tonnes.

Source: Global Carbon Project, Global Carbon Atlas. <http://www.globalcarbonatlas.org/en/CO2-emissions>.

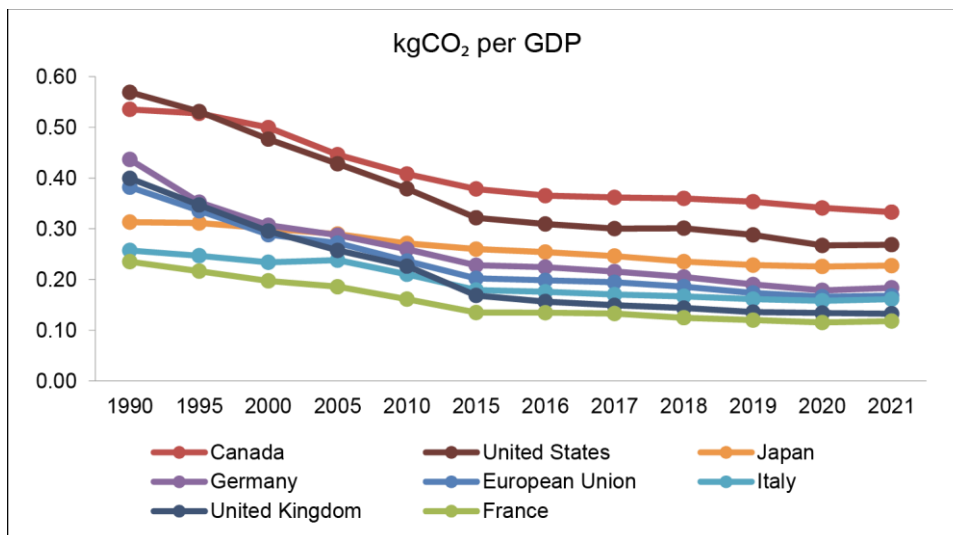
Figure A2: Carbon Dioxide Emissions from Fossil Fuels and Cement (tCO₂ per Person), 1990–2021



Carbon dioxide emissions from the use of coal, oil, and gas (combustion and industrial processes), the process of gas flaring, and the manufacture of cement. European Union is the average of the 27 member countries. t = metric tonnes.

Source: Global Carbon Project, Global Carbon Atlas. <http://www.globalcarbonatlas.org/en/CO2-emissions>.

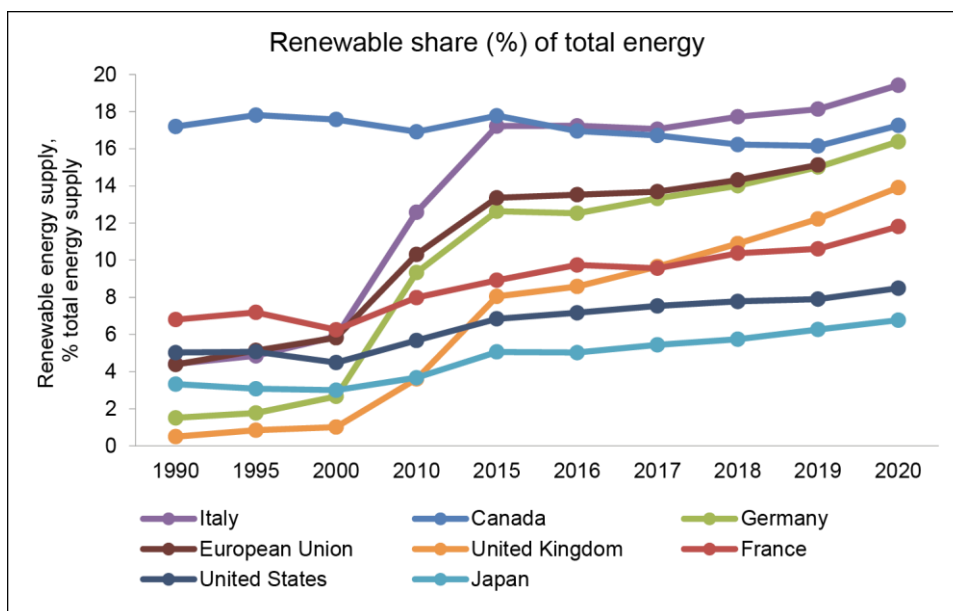
Figure A3: Carbon Dioxide Emissions from Fossil Fuels and Cement (KgCO₂ per GDP), 1990–2021



Carbon dioxide emissions from the use of coal, oil, and gas (combustion and industrial processes), the process of gas flaring, and the manufacture of cement. European Union is the average of the 27 member countries. kg = kilograms. GDP = gross domestic product.

Source: Global Carbon Project, Global Carbon Atlas. <http://www.globalcarbonatlas.org/en/CO2-emissions>.

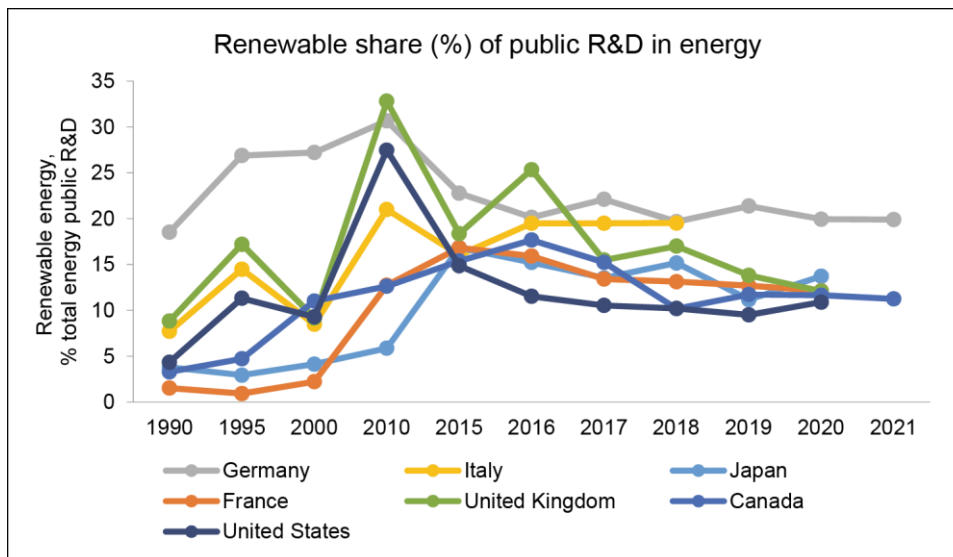
Figure A4: Renewable Energy Supply Share (%) of Total Energy Supply, 1990–2020



European Union is the average of the 28 member countries. G7 is the average of the seven member countries.

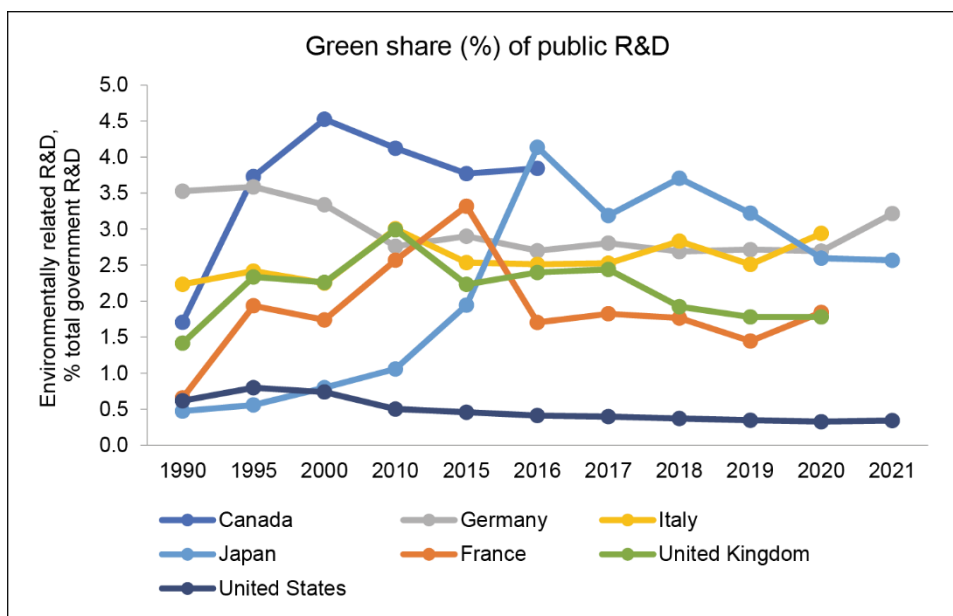
Source: OECD (2023). Green growth indicators. OECD Environment Statistics Database. <https://doi.org/10.1787/data-00665-en>.

Figure A5: Renewable Energy Share (%) of Total Public R&D Energy Budget, 1990–2021



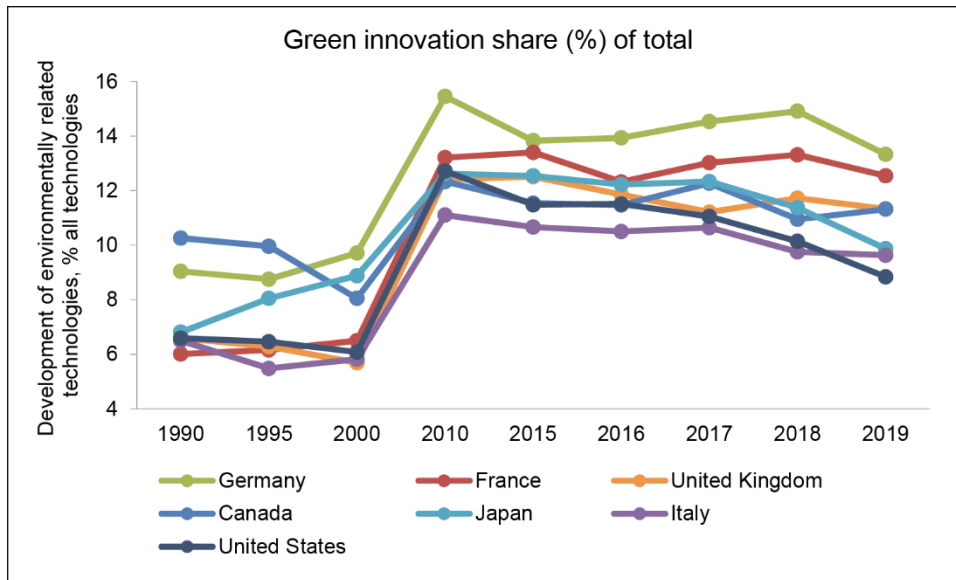
Source: OECD (2023). Green growth indicators. OECD Environment Statistics Database. <https://doi.org/10.1787/data-00665-en>.

Figure A6: Environmentally Related R&D Share (%) of Total Public R&D, 1990–2021



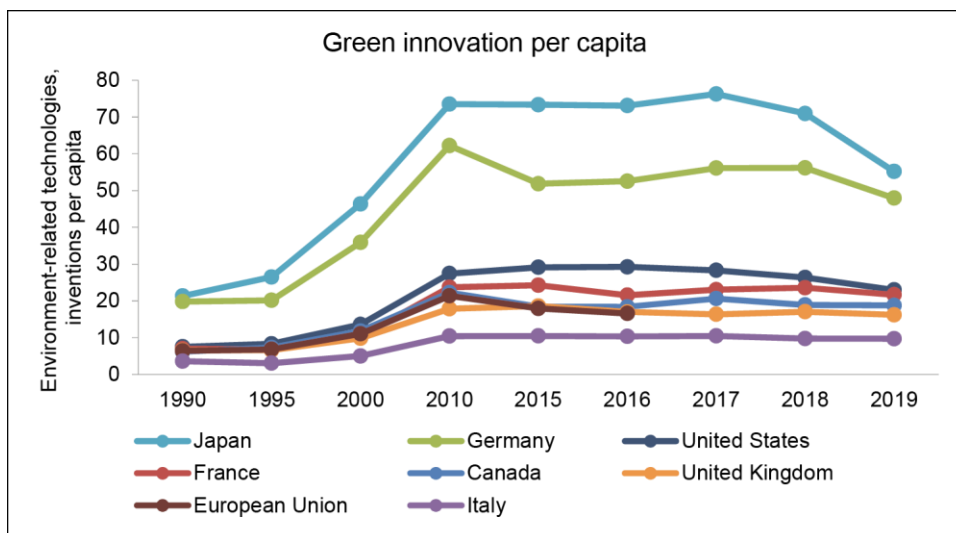
Source: OECD (2023). Green growth indicators. OECD Environment Statistics Database. <https://doi.org/10.1787/data-00665-en>.

Figure A7: Development of Environmentally Related Technologies as a Share (%) of All Technologies, 1990–2019



Source: OECD (2023). Green growth indicators. OECD Environment Statistics Database. <https://doi.org/10.1787/data-00665-en>.

Figure A8: Environmental Innovation per Capita, 1990–2019



European Union is the average of the 28 member countries.

Source: OECD (2023). Green growth indicators. OECD Environment Statistics Database. <https://doi.org/10.1787/data-00665-en>.