FISCAL POLICIES FOR REINFORCING KOREA'S CLIMATE MITIGATION STRATEGY[1]

The Korean authorities intend to leverage the COVID-19 recovery to transform their economy with a focus on becoming a global digital leader, transitioning from a carbon-dependent to a green economy, and enhancing social inclusiveness.[2] *The Korean New Deal (KND), announced in July 2020, provides a series of new policy interventions to help achieve these ambitions.*

In terms of the envisaged transition to a green economy, Korea's climate mitigation strategy encompasses several broad objectives, including achieving carbon neutrality by 2050 and reducing greenhouse gas (GHG) emissions 24.4 percent below 2017 levels by 2030. Many specific policy measures to make headway on these objectives are already implemented or have been announced, including Korea's Emissions Trading System (ETS)—the largest in scale outside the EU—covering about three quarters of domestic emissions; the recently announced Green New Deal (GND), which is a component of the KND; standards for the average emission rates of vehicle sales fleets and tax exemptions for EVs and HVs; and a renewable portfolio standard (RPS) requiring generators to increase their renewable share in the electricity mix.

Achieving Korea's climate objectives will require further strengthening of the mitigation framework in the period ahead. Additional measures should be effective, cost-efficient, build off and complement existing policies, and flexibly accommodate possible constraints on the acceptability of higher energy prices. With these criteria in mind, this paper lays out policy options for the authorities, presented as a comprehensive package that combines enhanced carbon pricing at the national (i.e., economy-wide) level and readily adjustable fiscal incentives to reinforce mitigation and other policies at the sectoral level. Articulating a clear, forward-looking policy framework for the achievement of Korea's climate ambitions, especially regarding carbon pricing, will be important to provide adequate incentives for private investment in the development and use of green technologies.

At the national level, the authorities could consider in Phase 4 of the ETS a trajectory of emissions caps fully aligned with meeting the 2030 emissions target; underpinning the ETS with exogenous and progressively rising price floors and ceilings; and a transition to full allowance auctions. These reforms would: (i) better align emissions with long-term carbon neutrality; (ii) promote across-the-board incentives for low-carbon investment for which a robust price signal is essential; (iii) improve compatibility with other instruments overlapping with the ETS (e.g., RPS); and (iv) raise additional revenues, which could help promote innovation in green industries, fund the clean energy transition, and lower taxes on work effort.

The reinforced ETS could be complemented at the sectoral level with feebates to enhance mitigation incentives in the transport, power, industrial, and building sectors (some elements of a feebate already apply in transportation). Feebates apply a revenue-neutral, sliding scale of fees on products or activities with above average emission rates and a sliding scale of rebates on products or activities with

[1] Prepared by Ian Parry. The author is grateful to Andreas Bauer for very helpful comments and suggestions and to Khamal Clayton and Si Guo for assistance on data and policy background.

[2] Ministry of Economy and Finance (2020).

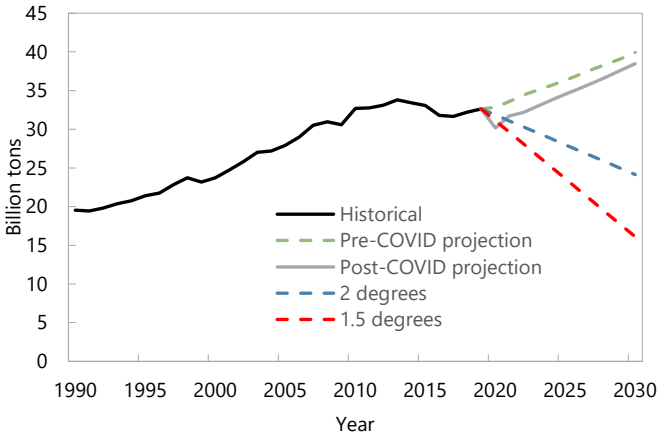
below average emission rates. Feebates: (i) can cost-effectively promote the full range of responses for reducing emissions intensity within a sector; (ii) avoid a fiscal cost to the government; (iii) avoid significantly higher (and politically challenging) energy prices; and (iv) are compatible with existing regulatory standards. A feebate variant could also promote carbon storage in the land use sector.

The paper concludes by discussing briefly the ongoing international debate on trade and coordination aspects of carbon mitigation. A key issue on the trade front is border carbon adjustment (BCA), which the EU plans to introduce in 2023 and Canada, the UK, and the United States are currently considering. BCAs help to alleviate the adverse impacts on industrial competitiveness from carbon-price-induced increases in energy prices and reduce the risk of 'emissions leakage'. The authorities should consider whether a BCA for energy-intensive, trade-exposed (EITE) industries might be an appropriate instrument for Korea, at some future point, perhaps after early experiences with an EU BCA. The coordination issue relates to discussions about an additional international mechanism to complement the Paris Agreement by scaling up action among key emitters in a multilateral way. One potential mechanism for this is an international carbon price floor (ICPF) among large emitters. Korea might usefully contribute to the international dialogue on an ICPF and other complementary mechanisms.

A. Introduction

1. The window of opportunity for containing global climate change to manageable levels is closing rapidly. Global carbon dioxide (CO_2) and other greenhouse gas (GHG) emissions must be cut 25–50 percent below 2018 levels by 2030 to be on track with containing projected warming to 1.5°–2°C above preindustrial levels with rapid reductions to emissions neutrality thereafter. Due to the pandemic-induced crisis, global emissions in 2020 are projected to fall about 8 percent below 2019 levels. However, without strong mitigation policies global emissions are likely to start rising again in 2021 as economies recover (Figure 1). With governments bringing forward investment plans to boost their economies, the pandemic has added to the urgency of ensuring this new investment is efficiently allocated to low-carbon technologies—this requires strengthening carbon pricing or equivalent measures to level the playing field for clean technologies

Figure 1. Global Fossil Fuel CO2 Emissions Trends



Source: IEA (2020), Fund staff estimates, IPCC (2018).

2. The Korean authorities have already announced a series of important emission mitigation goals. In its Intended Nationally Determined Contribution (INDC) submitted in September 2015 for the 2015 Paris Agreement, Korea set a medium-term goal of reducing GHG emissions by 37 percent from

business-as-usual (BAU) emissions of 851 million tons CO_2 equivalent ($MtCO_{2e}$) in 2030[3]—this target would imply cutting GHGs 22 percent below their 2017 level of 709 $MtCO_{2e}$. Last December, Korea updated and submitted its first NDC under the Paris Agreement. The updated target is to reduce GHGs 24.4 percent below 2017 GHG emissions by 2030. Earlier, Korea's President Moon Jae-In had announced a long-term goal of carbon neutrality by 2050, matching and in some cases exceeding the ambition of other large emitters.[4] Supplementary targets at the sectoral level in Korea include:

- Increasing the share of renewable power generation to 20 percent by 2030 and 30–35 percent by 2040 (up from 3 percent in 2017);[5]
- Increasing the number of EVs on the road to 3 million by 2030 (about 4 percent of the in-use fleet) and the number of HVs to 850,000.[6]

Policies for making headway on all these objectives (see below) are outlined in the third *Energy Master Plan* (adopted in June 2019 for the period up to 2040) and the eighth *Electricity Plan* (adopted in December 2017 for the period up to 2030).[7]

3. Korea also has the ambition to become a leader in the development and use of green technology. The Green New Deal (GND) announced by President Moon Jae-In in July 2020 sets aside public funding of KRW 42.7 trillion from 2020 to 2025 for green projects. The GND is one of three components of a broader Korean New Deal (KND) focusing the recovery from the pandemic on expanding employment and technological opportunities in growth sectors of the future—the other two components are investment in the digital economy and a strengthened employment and social safety net. [8] The GND contains projects for, among others, buildings; tree planting; renewables; and clean technology research such as green hydrogen and carbon capture, usage, and storage (CCUS). The GND is projected to leverage an additional KRW 30.8 trillion in local government and private funding and create 659,000 jobs (see Annex Table A1 for more details on the GND).

[3] See Government of Korea (2016).

[4] The EU, Japan, U.K., and the U.S. have also set carbon neutrality targets for 2050, while China has announced this target for 2060. See www.iea.org/reports/world-energy-outlook-2020/achieving-net-zero-emissions-by-2050. Carbon neutrality allows for a positive level of gross emissions but only if they are offset by processes to remove emissions from the atmosphere (e.g., afforestation, directly capturing emissions from the atmosphere).

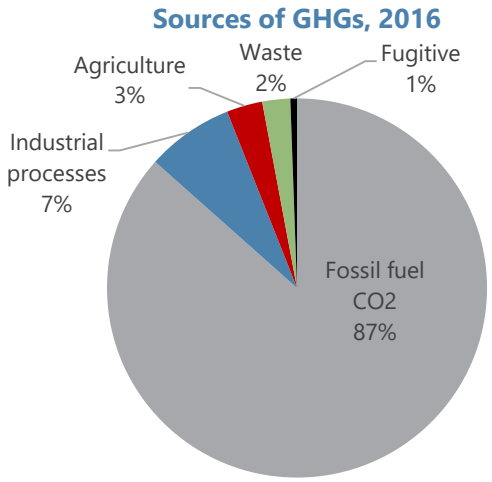
[5] The envisioned electricity generation mix in 2030 would be 24 percent nuclear, 36 percent coal, 19 percent natural gas and 20 percent renewables (MOTIE 2017).

[6] An intermediate target is 1.13 million EVs and 200,000 HVs by 2025, up from 91,000 and 5,000 each by the end of 2019. Unlike some other countries Korea has not set a target for the full phase out of internal combustion engine sales (see https://theclimatecenter.org/actions-by-countries-phase-out-gas).

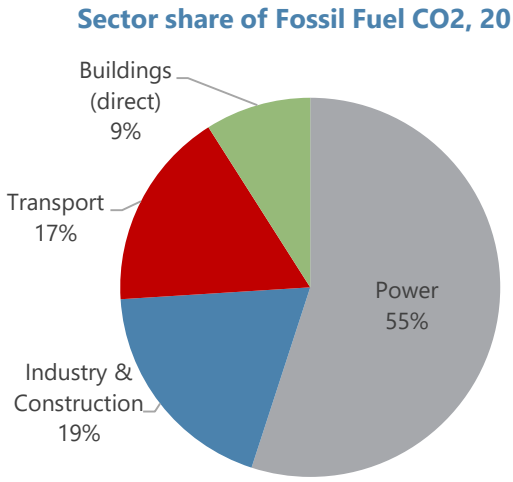
[7] See MOTIE (2019) and MOTIE (2017) respectively.

[8] Government of Korea (2020a).

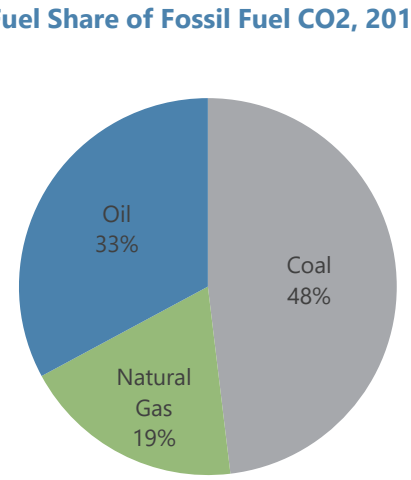
Figure 2. Korea: Breakdown of GHG Emissions



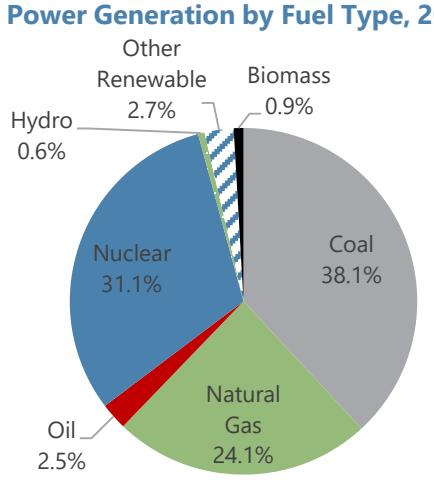
Source: UNFCCC (2020).



Source: Fund staff estimations.



Source: Fund staff estimates.



Source: Fund staff estimates.

4. Korea's GHG emissions arise mostly from fossil fuel CO_2 combustion. Fossil fuels accounted for 87 percent of Korea's 694 million tons in GHG emissions in 2016. Another 7 percent of GHGs were from industrial processes like cement production and fluorinated (F-) gases, 3 percent from agricultural sources, 2 percent from waste (e.g., methane leaks at landfills), and 1 percent are fugitive emissions (leaks from fuel extraction, storage, processing, and distribution). By sector, power generation accounted for 55 percent of fossil fuel CO_2 emissions in 2018, industry and construction 12 percent, transportation 17 percent, and (residential and commercial) buildings 9 percent—indirect emissions from electricity use in buildings are however 2.5 times the direct emissions.[9] By fuel type, coal accounted for 48 percent of fossil fuel emissions in 2018, oil 33 percent, and natural gas 19 percent. And in the power sector, coal accounted for 38 percent of generation in 2018,

[9] IEA (2020).

natural gas 24 percent, nuclear 31 percent, oil 2.5 percent, hydro 0.6 percent, and non-hydro renewables 2.7 percent.[10]

5. Staff projections suggest that with currently planned mitigation efforts, fossil fuel CO_2 emissions will increase 5 percent between 2018 and 2030.[11] Korea's CO_2 emissions increased by 161 percent between 1990 and 2018 (Figure 3), reflecting in part strong growth in the manufacturing sector.[12] Although GDP is projected to increase by another 25 percent between 2018 and 2030, the energy intensity of GDP is expected to fall 19 percent due to gradually improving energy efficiency and an assumption that energy demand will increase by less than GDP.[13] Emission growth is projected to be much higher in large emerging market economies over this period—47 percent in China and 37 percent in India. In absolute terms, without new or strengthening of existing mitigation policies, Korea is projected to be the 7th largest global emitter of CO_2 in 2030, and the fourth largest emitter in per capita terms (see Figure 3).

6. Korea's main policy for mitigating GHGs is the Emissions Trading System (ETS) launched in 2015, the first national ETS in East Asia. Table A2 in Annex I provides details on the design features of the ETS. The system in Phase 3 (2021–2025) will apply to 685 companies—principally power generators and large industrial firms (e.g., iron and steel, petrochemicals, cement, oil refineries, nonferrous metals, paper, textiles, machinery, mining, glass and ceramics) covering 73 percent of national GHGs, up from a coverage rate of 70 percent in Phase 2 (2018-2020).[14] The ETS cap cumulated over the three years of Phase II was 1,796 $MtCO_{2e}$, or on average 599 $MtCO_{2e}$ a year. In Phase 3 the annual average emissions cap will be reduced 4.7 percent relative to 2017–2019 ETS emissions. Allowances are largely given away for free (based on companies' 2011–2013 emissions) though 10 percent will be auctioned in Phase 3[15]—EITE industries will continue to receive

[10] Following recent investment in coal plants, and a 12 percent downward revision in needed generation capacity for 2030, there is currently excess generation capacity which provides headroom for a rapid expansion of renewables (Webb and Kim, 2018).

[11] IMF staff have developed a spreadsheet tool to project emissions on a country-by-country basis and the emissions, fiscal, and economic impacts of carbon pricing and other mitigation instruments. The model starts with recent data on use of fossil and other fuels by major energy sector and then projects fuel use forward using (post-COVID) GDP projections and assumptions about: (i) the income elasticity of demand for energy products; (ii) technological progress that improves energy efficiency and the productivity of renewables; and (iii) future international energy prices. The impact of carbon pricing (and other policies) on fuel use depends on their proportionate impact on future energy prices and fuel price responsiveness—price elasticities are between -0.5 to -0.8 based on empirical evidence and results from energy models. See IMF (2019a and b) and Parry and others (2020) for descriptions and applications of the model.

[12] For example, Korea is the fifth largest car manufacturing country (OICA 2019).

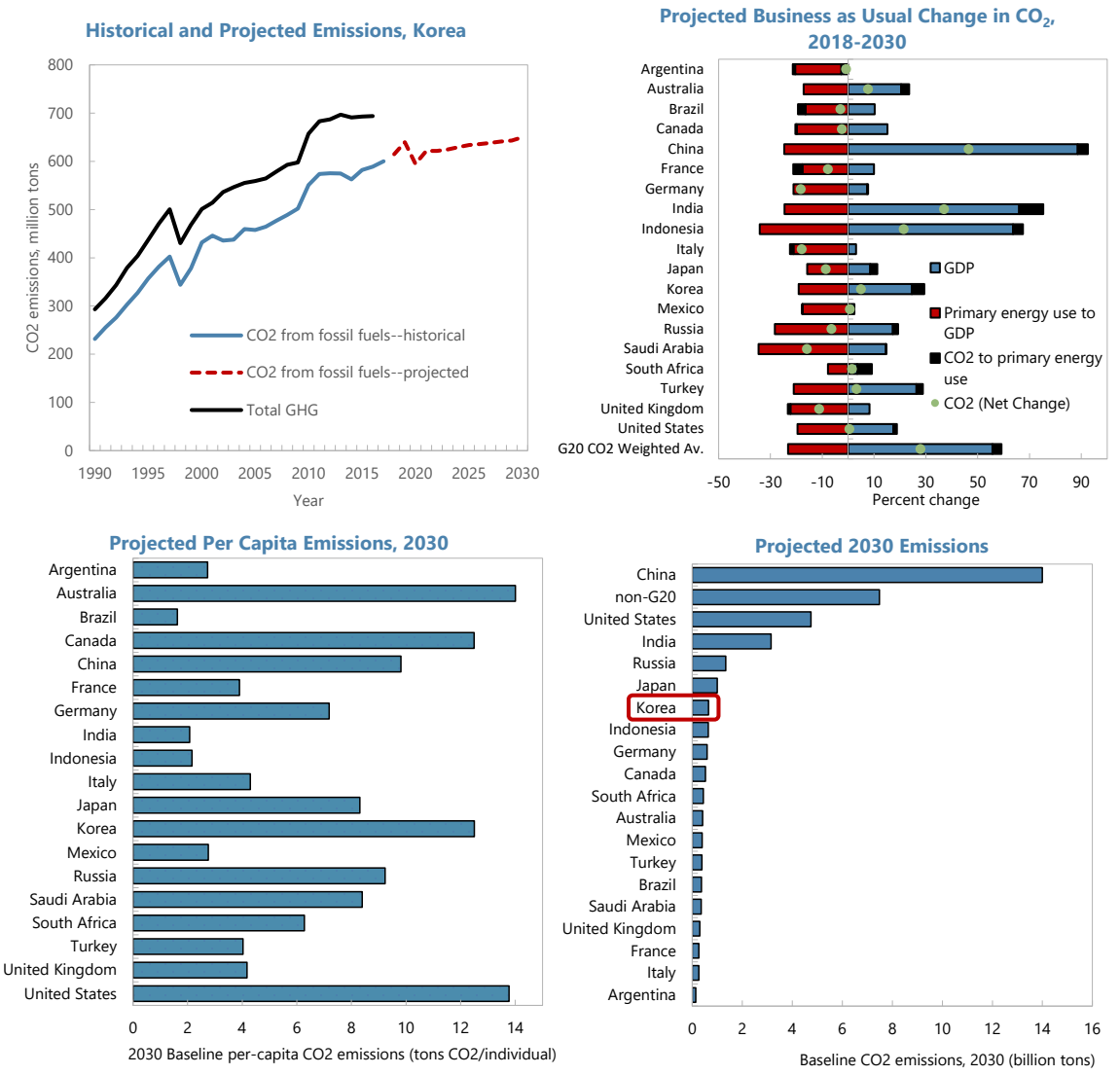
[13] This accounts for a 7 percent fall in emissions between 2019 and 2020 due to the global pandemic. CAT (2020) projects 2030 GHG emissions in Korea will be between 7 percent lower and 4 percent higher than 2018 (depending on the eventual impact of the COVID-19 crisis). Government of Korea (2019) previously projected faster growth of energy-related emissions—an increase of 22 percent between 2016 and 2030.

[14] Companies with over 125 kilotons, and installations with over 25 kilotons, of annual CO_2 equivalent emissions are covered by the scheme. The construction, public, waste, and domestic aviation sectors are also covered and all six Koyoto GHGs, though other emissions are small relative to CO_2.

[15] For comparison, 57 percent of allowances will be auctioned over the current phase (2013-2020) of the EU ETS (ICAP 2020b).

100 percent free allowance allocations.[16] Auctions are subject to a minimum price based on recent emissions prices. Various banking and borrowing provisions, and other market stability provisions, are designed to limit allowance price volatility.

Figure 3. Fossil Fuel CO_2 Emissions Trends



Source: Fund staff estimates.

7. Other policies provide additional incentives for renewables, low emission vehicles, and energy efficiency.

[16] EITE sectors are defined along the following criteria: (i) trade intensity of at least 10 percent and the ETS increases production costs for the industry by at least 5 percent; or (ii) production cost increases exceed 30 percent; or (iii) trade intensity exceeds 30 percent.

- The Renewable Portfolio Standard (RPS), in place since 2012, requires the 23 major electric utilities power (i.e., those with over 500MW) to increase their renewable share in the electricity mix to 10 percent by 2022.[17]

- Korea is tightening its vehicle emissions standard to 97 grams (g) of CO_2 per km by 2020 for passenger vehicles (80 percent of the new vehicle fleet), which is comparable to new EU standards, and to 166 g CO_2 per km for light trucks (20 percent of the fleet).[18] EVs and HVs also benefit from exemption of: (i) local acquisition tax (7 percent of vehicle price, which can save up to KRW 1.4 million); (ii) national individual consumption tax (5 percent of vehicle price, which can save up to KWR 3 million for an EV and KWR 4 million for an HV).

- For the building sector, Korea is gradually applying stricter energy conservation designs to new structures, while for industry the focus is on energy efficiency and clean fuel and materials.[19]

8. Korea also imposes significant excises on fossil fuels, although (as in other countries) these generally undercharge, or only just charge, for non-carbon externalities. Unlike most other countries, Korea imposes a significant coal tax, recently increased to KRW 46 per kg, equivalent to US$2 per gigajoule (GJ) or $21 per ton CO_2. Local air pollution damages (i.e., elevated mortality risks for exposed populations) from coal use in Korea would warrant a tax almost twice as high however—these damages are estimated at $3.8 per GJ. Excises on gasoline are KRW 770 per liter, equivalent to US$0.64 per liter or $272 per ton CO_2, while excises on (road) diesel are KRW 540 per liter equivalent to $0.45 per liter or $166 per ton of CO_2. Despite these high taxes, retail fuel prices for diesel are still somewhat less than prices needed to reflect supply costs, non-carbon environmental costs, and general consumption taxes, while gasoline prices just about reflect these factors.[20] Other countries generally undercharge for coal, gasoline, and diesel fuel, before even counting global warming costs (see Figure 4).

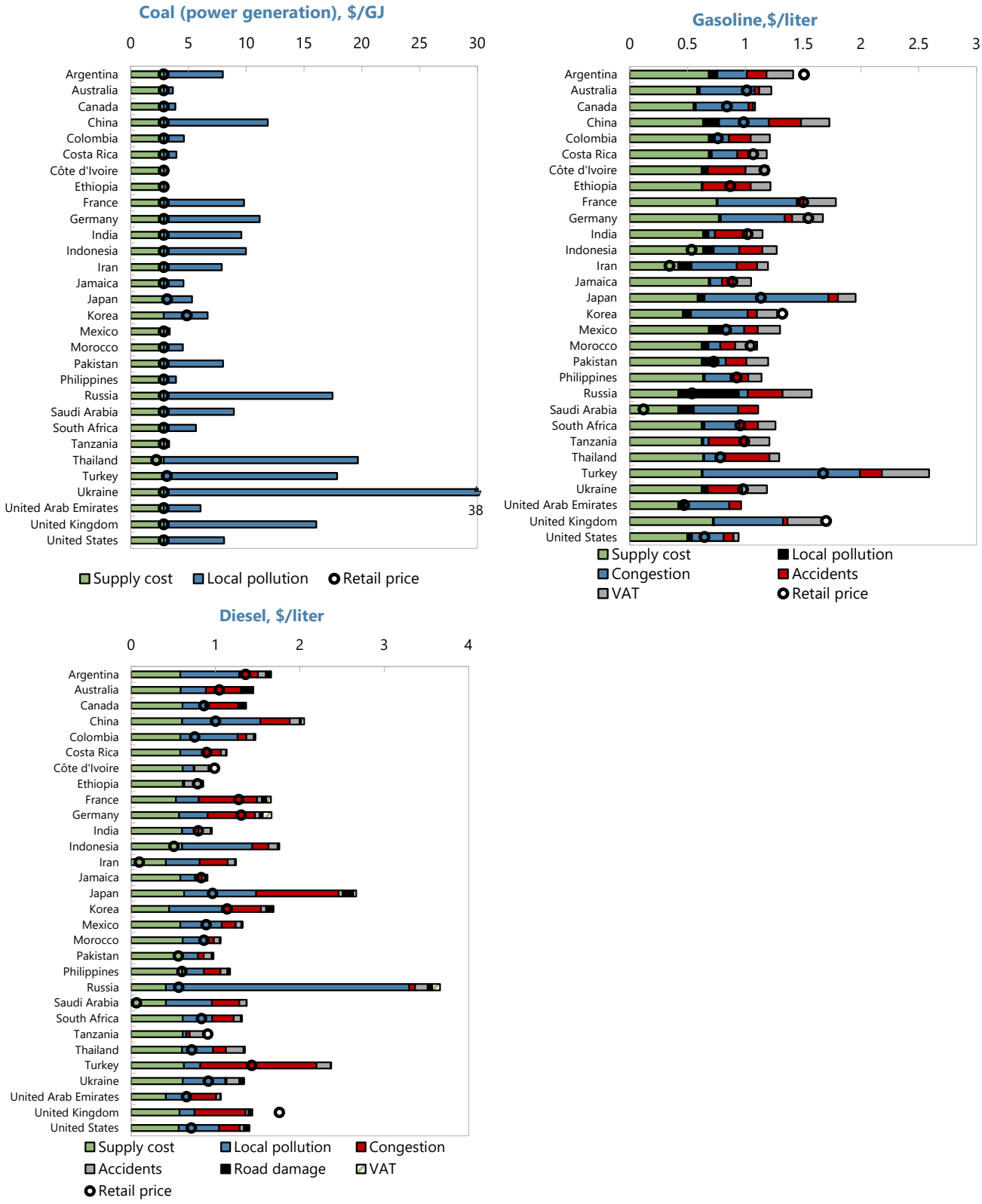
[17] Korea New and Renewable Energy Center (2019). "New energy" technologies (e.g., coal-fired integrated gasification combined cycle plants) could also count towards meeting the requirement but they are expected to play only a minor role at best. To help meet their compliance requirements, generators can purchase Renewable Energy Certificates from other generators that exceed the RPS requirement.

[18] These targets represent a reduction in emission rates of 31 percent and 15 percent relative to respective emission rates in 2013. Standards will tighten to 89 (cars) or 158 (trucks) g CO_2 per km by 2025, and 70 (cars) or 146 (trucks) g CO_2 per km by 2030. Credit trading is permitted among manufacturers. See www.transportpolicy.net/standard/south-korea-light-duty-fuel-economy-and-gh.

[19] APERC (2019), Ministry of Environment (2018).

[20] Some level of fuel taxation is efficient to reflect external costs of driving including traffic congestion, accidents, and local air pollution—at least until more efficient instruments like km-based charging systems on congested roads are widely applied. See Parry and others (2014) for an extensive discussion of efficient fuel taxes and methods for quantifying them.

Figure 4. Current Prices, Supply, and non-Carbon Environmental Costs, Selected Fuels and Countries, 2015



Source: Coady and others (2018).

9. Achieving Korea's mitigation objectives will require further strengthening of this policy framework in the period ahead. For example, emissions caps in phase 4 of the ETS will need to be aligned with 2030 commitments and current policies will need reinforcing to meet sectoral targets (e.g., for renewables)—see below. This paper lays out policy options for the authorities, presented as a comprehensive package that includes enhanced national-level (i.e., economy-wide) carbon pricing and feebates at the sectoral level, building on and reinforcing the existing regulatory and fiscal framework. Section B discusses strengthening the ETS; Section C discusses sectoral policies; Section D briefly covers BCAs and international coordination; and Section D summarizes the policy advice

B. Strengthening Korea's ETS

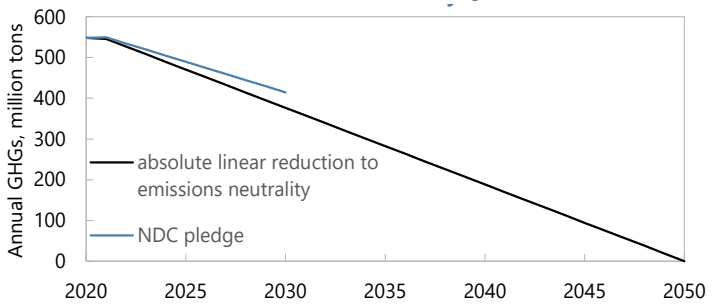
10. Carbon pricing has a critical role to play in climate mitigation. Pricing:

- Provides across-the-board incentives for firms and households to reduce energy and shift to cleaner fuels (by reflecting the cost of carbon emissions in the prices of fuels, electricity, and goods);
- Automatically minimizes mitigation costs (by equalizing the cost of the last ton of CO_2 reduced across fuels and sectors);
- Redirects new investment to clean technologies (if there is a robust and rising price signal);
- Mobilizes potentially substantial government revenues (which can be used to address distributional concerns and to boost the economy); and
- Generates substantial domestic environmental benefits (e.g., reductions in local air pollution mortality).

11. The authorities can rely on the existing ETS as their central tool for carbon pricing in Korea. The ETS already has relatively good coverage compared with pricing schemes in most other countries (see Table 1). However, there is room for further strengthening the ETS as emissions caps are not fully aligned with intermediate mitigation goals, future emissions prices are uncertain, and revenue opportunities for the government are not fully exploited.

12. Consistency with a linear pathway to emissions neutrality would imply tightening the ETS emissions cap. On a linear pathway from current emissions to emissions neutrality in 2050, the ETS emissions cap would average 509 million tons over 2021-2025, or 7 percent below annual emissions in Phase 2, and 416 million tons over 2026-2030, or 24 percent below Phase 2 (Figure 5). On a linear pathway consistent with

Figure 5. Korea: ETS Emissions Caps Under Pathways to Emissions Neutrality

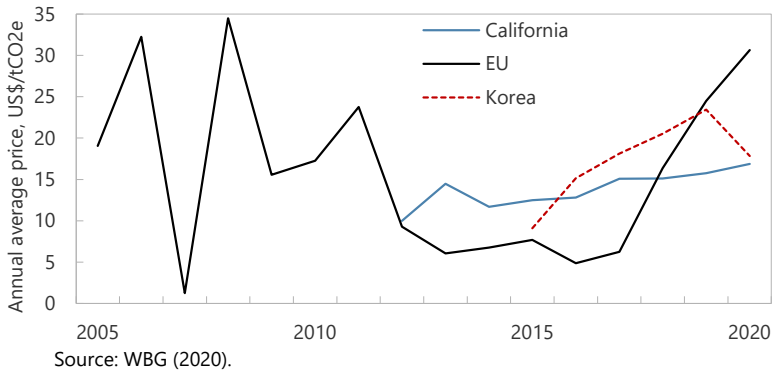


Source: Fund staff estimates.
Note. 2020 emissions is the annual cap in Phase 2 scaled up 3 percent due to expanded coverage from 2020.

Korea's NDC pledge for 2030, the average cap would be 19 percent lower than the Phase 2 average.[21] For comparison, in the third phase of the EU ETS, the annual emissions cap is set to decline by 2.2 percent each year between 2021 and 2030 and beyond, though a faster contraction in the cap will now be needed in light of the recent strengthening of the EU's mitigation pledge for 2030.[22] Korea's ETS could be strengthened by: (i) scaling back the cap by a fixed amount each year (an absolute ton reduction or a percent reduction as in the EU); and (ii) ensuring alignment of the trajectory of emissions caps with emissions pathways consistent with medium- and long-run long run emissions targets.

13. Recent allowance prices in the Korean ETS have been broadly in line with comparators and carbon pricing schemes more generally (Figure 6 and Table 1), but uncertainty about future prices could hold up low carbon investments desired by the government. In addition, the ETS is not fully compatible with overlapping mitigation instruments which tend to reduce emissions prices (rather than emissions) given the fixed cap. The minimum auction price could be set exogenously (rather than depending on previous emissions prices) with a price floor that ramps up predictably over time. An exogenous price floor would increase certainty over emissions prices and lower the risk that overlapping policies (e.g., the RPS) lower allowance prices (if the floor is binding, overlapping instruments lead to automatic withdrawal of allowances from the system).[23] If future emissions caps are tightened, an exogenous price ceiling (which puts additional allowances into the system) may also be needed to limit risks of a backlash against high energy prices. Another way to increase price certainty would be to link the Korean ETS with other trading systems (e.g., in the EU), but then prices would be largely determined outside of Korea—it may be preferable to retain discretion over setting the bands for domestic emissions prices (which can be adjusted according to national circumstances and progress on pricing elsewhere).

Figure 6. History of Prices in ETSs



Source: WBG (2020).

[21] Some backloading of emissions reductions to later in the transition period (than on a linear pathway) may be appropriate (given the long-lived nature of existing fossil fuel capital like coal plants) though this would imply a larger cumulative amount of emissions during the transition.

[22] The pledge was raised from 40 to 55 percent below 1990 levels by 2030.

[23] See Flachsland and others (2018) for discussion of price floor mechanisms.

14. The Korean ETS does not take full advantage of fiscal opportunities from carbon pricing, which in turn can imply higher overall costs for the economy and adverse distributional effects.

Table 1. Selected Carbon Pricing Schemes, 2020

Country/Region	Year Introduced	Price 2020, $/Ton CO_2	Coverage of GHGs Million Tons	Coverage of GHGs Percent
Carbon taxes				
Chile	2017	5	58	39
Colombia	2017	4	46	24
Denmark	1992	26	25	40
Finland	1990	68	41	36
France	2014	49	172	35
Ireland	2010	28	32	49
Japan	2012	3	909	68
Mexico	2014	<1-2	381	47
Norway	1991	3-53	47	62
Portugal	2015	26	16	29
South Africa	2019	7	512	80
Sweden	1991	119	44	40
Switzerland	2008	99	6	33
Emissions Trading Systems				
California	2012	17	375	85
European Union	2005	31	2,249	45
Germany	2021	29	238	31
Korea	2015	18	489	70
New Zealand	2008	14	45	51
Regional GHG Initiative	2009	5	108	18
Carbon price floors				
Canada	2019	22	71	9
United Kingdom	2013	22	136	23

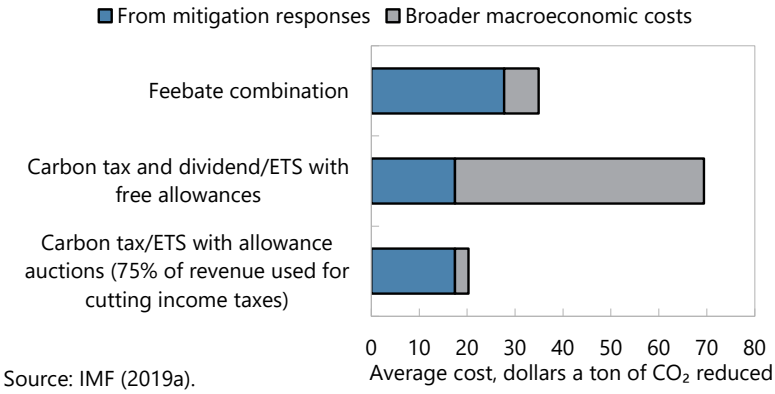
Source: WBG (2020) and Fund staff estimates.

- Free allowance allocations reduce potential revenue from allowance auctions and thus divert revenues away from the government budget. These revenues could be used to boost growth and employment, for example, by lowering taxes on work effort and creating incentives for innovation and socially productive investment, including in green technology where Korea aspires to take a leading position. Full allowance auctions in the Korean ETS in 2019 would have raised revenues of about 0.5 percent of GDP. A recent IMF assessment for the United States suggests that the most cost-effective policy—for a given nationwide emissions reduction—is by far an ETS with allowance auctions, or a carbon tax, with the bulk of revenues used to cut distortionary taxes on labor and business income or otherwise increase economic efficiency (Figure 7). Policies like feebates (explained below) that exploit opportunities for reducing emission rates and improving energy efficiency, but without a significant impact on energy prices, can also be more cost-effective than pricing schemes with free allowances that forego the economic efficiency gains from revenue recycling.[24]

[24] By raising energy prices, carbon pricing slightly contracts overall economic activity as it increases the general price level, which in turn reduces the real returns to work effort and investment. This causes some compounding of distortions in factor markets created by taxes on labor and capital income. In contrast, feebate and similar policies have much smaller impacts on energy prices, and hence cause smaller macroeconomic costs, because they do not involve the pass through of tax revenue or allowance rents in higher energy prices. A substantial analytical literature has explored these issues—see, for example, Goulder and others (1999), Parry and Williams (2012).

- Another drawback of free allowance allocation is that it can have adverse distributional consequences. Allowance rents in non-EITE sectors may be largely passed forward in higher consumer prices, creating windfall profits for firms and their shareholders (who tend to be concentrated in higher income groups).[25] In many cases, a key motivation for free allowance allocations is that they provide assistance for EITE industries. However, such assistance might be provided more efficiently through other means (see below).

Figure 7. United States: Efficiency Costs of $50 Carbon Tax or Equivalent Instruments, 2030



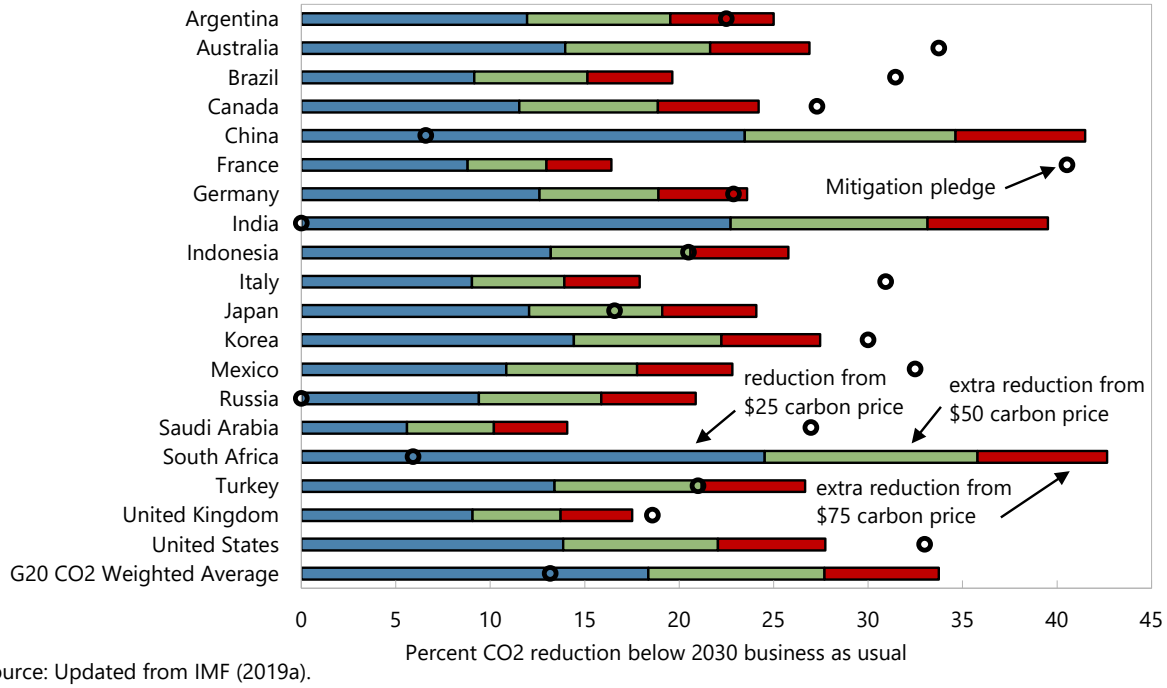
Source: IMF (2019a).
Note: All policies reduce economywide CO_2 22 percent below baseline levels. ETS with free allowance allocations ignores indirect revenue gains from business taxes on allowance rents.

15. High carbon prices are generally needed to achieve substantial emissions reductions, in Korea and other countries, if pricing is the only instrument used. For illustration, meeting Korea's NDC pledge exclusively through carbon pricing would require raising the 2030 CO_2 price by more than KRW 83,333 ($75) per ton on all fossil fuel CO_2 emissions from the current level ($18 per ton), and applying similar pricing or equivalent measures to other GHGs. CO_2 emissions are somewhat more responsive to pricing in Korea than in most other G20 countries (see Figure 8). This is due mainly to the higher share of coal in CO_2 emissions in Korea, implying that other countries would need even higher prices than Korea for meeting a comparable emissions target. Prices elsewhere may increase sharply in the next decade—for example, Canada has announced it will ramp up its carbon price to US$135 by 2030 and there will be upward price pressure in the EU ETS following the recent tightening of the EU's 2030 emissions target.

16. High carbon prices are often subject to acceptability constraints because of the impact on energy prices. For instance, an illustrative $50 per ton carbon price in 2030 would increase coal prices in Korea 156 percent, natural gas prices 33 percent, and retail electricity prices 36 percent. Higher electricity prices may also be at odds with long-term objectives for decarbonization through electrification of transportation and heating. Pump prices for gasoline would only increase 4 percent however, and the proportionate increases in energy prices tend on average to be about as large for other G20 countries as for Korea (Table 2).

[25] Parry (2004).

Figure 8. CO_2 Emissions Reductions for Mitigation Pledges and from Carbon Pricing



Source: Updated from IMF (2019a).
Note. Mitigation pledge is from Paris Agreement or subsequent national pledge. Price is additional to any existing pricing.

17. A comprehensive policy strategy could enhance the feasibility of stronger carbon pricing in support of Korea's mitigation objectives. Past experiences with energy and carbon pricing reform across the globe suggests that acceptability challenges can be overcome with a comprehensive approach that combines different policy instruments and levers:[26]

- A balance between national level pricing and reinforcing sectoral instruments, which are less efficient but often politically more acceptable (see below);
- Transparent, productive, and equitable use of carbon pricing revenues—for example, a carbon price of $50 applied to all fossil fuel CO_2 in Korea would raise revenues of 1.4 percent of GDP in 2030 with full allowance auctions;
- Assistance for vulnerable groups (low-income households, displaced workers, vulnerable regions, EITE industries—see below); and
- Extensive consultations with key stakeholders to garner their support and programs informing the public of the rationale for reform and how they benefit (e.g., from recycling of revenues and improved local air quality).

[26] See Coady and others (2018).

Table 2. Impact of $50 per ton Carbon Tax on Energy Prices in 2030, G20 Countries

Country	Coal		Natural gas		Electricity		Gasoline	
	BAU price, $/GJ	% price increase	BAU price, $/GJ	% price increase	BAU price, $/kWh	% price increase	BAU price, $/liter	% price increase
Argentina	2.9	211	2.6	100	0.08	40	1.2	10
Australia	2.9	148	8.5	33	0.10	53	1.2	11
Brazil	2.9	156	2.6	99	0.12	6	1.3	9
Canada	2.9	173	2.6	94	0.10	8	0.9	13
China	2.9	159	8.5	32	0.09	51	1.1	9
France	4.9	84	7.9	35	0.12	2	1.7	6
Germany	5.2	91	7.9	34	0.13	14	1.7	6
India	2.9	159	8.5	20	0.09	65	1.2	10
Indonesia	2.9	165	8.5	27	0.11	53	0.5	26
Italy	5.2	91	7.9	35	0.13	14	1.8	6
Japan	2.9	158	8.5	33	0.11	32	1.3	8
Korea	2.9	156	8.5	33	0.14	36	1.4	4
Mexico	2.9	156	2.6	110	0.09	55	0.9	13
Russia	2.9	134	6.6	36	0.13	20	0.8	12
Saudi Arabia	2.9	162	6.6	40	0.19	28	0.5	23
South Africa	2.9	145	6.6	17	0.07	78	1.1	13
Turkey	2.9	159	6.6	41	0.09	32	1.4	8
United Kingdom	5.7	101	7.9	35	0.13	10	1.6	6
United States	2.9	170	2.6	103	0.08	39	0.7	15
Simple Average	3.4	146	6.4	50	0.1	34	1.2	11.0

Source: IMF staff calculations.
Note: BAU prices are retail prices estimated in Coady and others (2019), including preexisting energy taxes, and adjusted for projected changes in international reference prices. BAU prices for coal and natural gas are based on regional reference prices. BAU prices for electricity and gasoline are from cross-country databases. Impacts of carbon taxes on electricity prices depend on the emission intensity of power generation. GJ = gigajoule; kWh = kilowatt-hour.

18. In summary, carbon pricing should remain the centerpiece of Korea's mitigation strategy, but it could be strengthened by aligning Phase 4 remissions caps with the 2030 emissions target, setting exogenous and progressively rising floor and ceiling prices under the ETS to enhance price certainty, and transitioning to full allowance auctions. These refinements would be mutually reinforcing and would increase the effectiveness of carbon pricing at cutting emissions and promoting low-carbon investment, enhance compatibility with overlapping instruments, while providing more revenue to support the GND or other budgetary priorities. A flexible approach may be needed however, for example price floor and ceiling trajectories may need to be adjusted in response to future progress technology development and on carbon pricing in other key emitting countries.

C. Sectoral-Based Policies

19. Sectoral mitigation instruments have a critical role to reinforce carbon pricing, though insofar as possible they should rely on the price mechanism to contain costs on the economy.

Acceptability constraints on pricing imply a need for sectoral instruments. And even with aggressive carbon pricing, additional instruments may be needed to achieve sectoral targets, especially for sectors with low responsiveness of emissions to pricing (this will imply some divergence in implicit carbon prices across sectors). Broader market failures (e.g., associated with clean technology infrastructure networks, or knowledge spillovers from new technologies) may also warrant additional policies, though often these should be targeted at specific technologies (e.g., power grid extensions, battery storage). Where the objective of sectoral instruments is to mimic key behavioral responses that would be induced by pricing, ideally, they would be designed flexibly, allowing firms and households to choose responses that minimize costs for a given emissions reduction.

20. The discussion below focuses on feebates as a sectoral instrument that can complement Korea's ETS. Feebates apply a sliding scale of fees to products or activities with above average emission rates and a sliding scale of rebates to products or activities with below average emission rates. Feebates can maintain revenue neutrality over time through updating of the 'pivot point', that is, the emission rate above/below which fees/rebates apply. Feebates reduce the emissions intensity of products or activities but without the same demand response as carbon pricing (e.g., reductions in electricity demand or in vehicle km driven), as they do not involve the pass through of carbon tax revenues or allowance rents in higher energy prices. For the same reason however, they may have greater political traction than pricing. Feebates are the fiscal analogue of emission rate regulations but they are automatically cost effective (regulations require extensive credit trading to be cost effective) and they provide ongoing incentives to reduce emissions (the average firm has no incentive to go beyond the standard under regulation). Feebates also promote a wider range of mitigation responses than clean technology subsidies and they avoid a fiscal cost. The discussion takes in turn applications of feebates to the sectors of road transportation, power, industry, buildings, and forestry—other emissions sources including from agriculture, F-gases, and waste sites are discussed in Annex II.

Transportation

21. Replacing EV and HV tax exemptions with a more comprehensive feebate would provide stronger incentives for progressively and cost-effectively decarbonizing the vehicle fleet as envisaged in the GND, while avoiding a fiscal cost to the government. For passenger vehicles, a comprehensive feebate would apply a fee to vehicle sales given by:

$$CO_2 \text{ price}$$

$$\times \{CO_2/\text{km} - CO_2/\text{km of the new vehicle fleet}\}$$

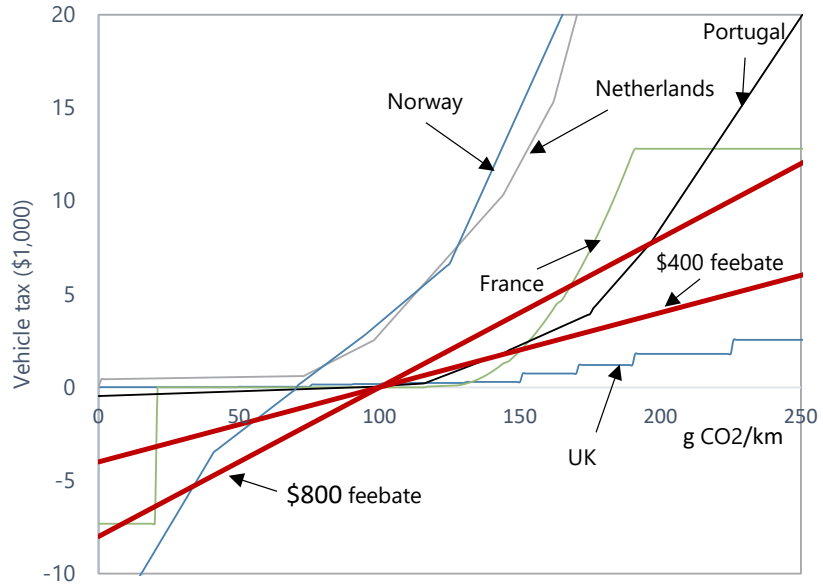
$$\times \{\text{lifetime vehicle km of the average vehicle}\}$$

Certified CO_2/km emissions by model type (currently used to administer vehicle emissions standards) can provide the data needed to assess the fees and rebates for each vehicle. The feebate has several desirable features as it:

- Promotes the full range of behavioral responses for reducing emission rates—shifting from high emission to low emission conventional vehicles and from these vehicles to EVs and HVs (EV and HV subsidies only promote the latter responses)—as there is always a continuous reward (lower taxes or higher subsidies) from switching from any vehicle with a higher emission rate to one with a lower emission rate[27];
- Is cost effective as the reward is always proportional to the reduction in the emission rate; and
- Maintains (approximate) revenue neutrality (unlike EV and HV subsidies which have a net fiscal cost)—by definition, fees offset rebates as the average CO_2/km in the formula is updated over time.

22. For illustration, a feebate with a price of $400 per ton CO_2 would apply a rebate of $4,000 for EVs and HVs and a fee of $4,000 for a vehicle with CO_2 emission rate of 200 g CO_2/km. These rebates and fees would be twice as high under a feebate with a price of $800 per ton.[28] Some European countries with elements of feebates generally impose even higher taxes on high emission vehicles than these illustrative feebates (Figure 9). Subsidies for EVs and HVs would decline over time as the average fleet emission rate declines, which is appropriate as the cost differential between clean vehicles and their gasoline counterparts falls over time (e.g., with improvements in battery technologies[29]). Gauging how fast the average emission rate falls in the future in response to a given feebate price is tricky given uncertainty about how the composition of vehicle sales is affected

Figure 9. CO_2-Based Components of Vehicle Taxes, Selected Countries



Source: ACEA (2018) and Fund staff estimates.
Note. Feebates assume fleet average emission rate of 100 g CO_2/km and discounted lifetime driving of 100,000 km.

[27] Vehicle manufactures are therefore rewarded for going beyond the CO_2/km standard (and penalized for falling short of it). The current system does include elements of a feebate in the sense that conventional vehicles are subject to a 5 percent excise while EVs and HVs are not. The system, however, provides only blunt incentives to reduce emissions—for example, conventional vehicles with the same price pay the same tax even though they may have very different emission rates.

[28] For comparison, current tax exemptions in Korea provide a subsidy for EVs of up to $4,000.

[29] EV battery costs have declined 90 percent over the last decade (see www.bloomberg.com/graphics/2020-peak-oil-era-is-suddenly-upon-us).

by changes in relative vehicle prices—the feebate price is, however, easily scaled up if needed to speed up the adjustment.

Electric Utilities

23. The current RPS is insufficient for meeting renewable energy targets in power generation. Studies suggest that under current policies Korea will fall short of meeting its targeted 20 percent renewable energy share by 2030.[30] The RPS ratio is however expected to be raised to meet mid-to-long-term renewable energy targets— a 20 percent renewable energy share by 2030 and 30 to 35 percent by 2040. The RPS could be reinforced with a feebate applied to electric utilities. Under a feebate scheme for this sector, utilities would be subject to a fee depending on the average emissions associated with the power generation they purchase given by

$$CO_2 \text{ price}$$
$$\times \{CO_2/kWh - \text{industry-wide average } CO_2/kWh\}$$
$$\times \text{ electricity sales}$$

The feebate cost-effectively, and in a revenue-neutral way, promotes the full range of responses for reducing emission rates per kWh. These include improving generation efficiency and shifting of fuels from coal to gas and from these fuels to fossil plants with CCUS and renewables.[31] In contrast, the RPS promotes only the last of these responses. A feebate would complement the RPS in the sense that utilities would be rewarded (through rebates) for going beyond the RPS standard. Indeed, there seems ample potential to accelerate the transition to carbon-free generation in Korea, with the right incentives in place.[32] Fast action to de-carbonize electricity generation is a critical first step for reducing emissions in other sectors, where electrification will play an important role.

24. For illustration, a feebate with a price of $50 per ton would currently apply a subsidy of 3.5 cents per kWh for zero-carbon electricity and a fee of 1.4 cents per kWh for coal plants (see Figure 10). Natural gas generation would receive a subsidy of 1.5 cents per kWh. Subsidies for renewables and natural gas, however, would decline over time (eventually turning into a fee in the case of gas), while the fee on coal would increase, as the average emission rate of electricity declines over time.

[30] See for example APERC (2019). CAT (2020) projects a renewable energy share of 8-17 percent in 2030 under current policies.

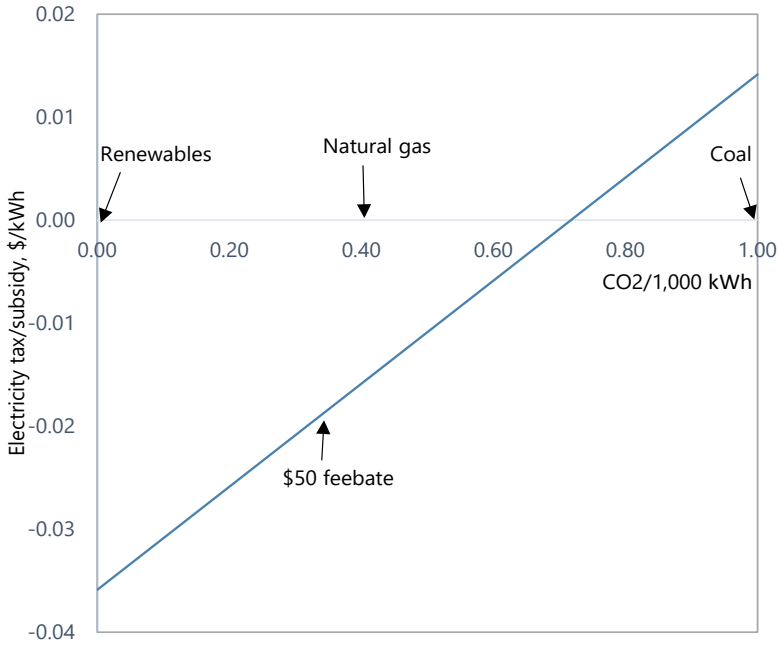
[31] In principle, shifting to nuclear power would be another option though Korea plans to phase out nuclear by 2083.

[32] Some studies suggest that a renewable share of more than 50 percent of generation in 2030 would be feasible for Korea (Climate Analytics, 2020), largely due to the expansion of solar photovoltaics and wind.

Industry

25. Feebate schemes for industries could be considered to reinforce incentives for reducing emissions if the government faces constraints on carbon pricing. The burden of carbon pricing on industry—prior to compensation schemes like free allowance allocations—consists of the costs of cutting emissions (e.g., from switching to cleaner but more expensive technologies) and the, typically much larger, allowance purchase payments for remaining emissions (see Annex III). Under a feebate scheme the latter component would be absent for the average firm and in this sense the feebate could be easier to scale up. Specifically, under a (revenue-neutral) feebate firms would pay a fee (or receive a transfer) given by

Figure 10. Illustrative Feebate for Electric Utilities



Source: Fund staff estimates.

$$\begin{aligned} &CO_2 \text{ price} \\ &\times \{CO_2/\text{production} - \text{industry-wide average } CO_2/\text{production}\} \\ &\times \text{production} \end{aligned}$$

For a given industry, the feebate would apply to the same firms as currently covered by the ETS, thereby limiting extra administration as emissions for these firms is already monitored. Annex III provides illustrative comparisons of the impacts of carbon pricing and feebates on production costs in the steel and cement industries.

Buildings

26. Improvements in the energy efficiency of new and existing buildings, and appliances used in buildings, reduce both direct emissions and (through lowering electricity demand) indirect emissions.[33] These improvements may however be hindered by possible market failures (e.g., liquidity constraints, cost-benefit mismatches between owners and renters, unawareness or uncertainty of energy savings from renovation).[34] The Korean government sets energy efficiency

[33] Promoting electricity conservation is still important, even if power generation were fully decarbonized, to ensure demand/supply balance given constraints on renewable generation sites.

[34] See for example Arregui and others (2020).

standards for a wide range of products (e.g., air conditioners, washing machines, TVs, lighting, refrigerators); provides tax credits for energy efficiency upgrades in buildings; sets codes for the design, construction, alteration, and maintenance of buildings; and improves consumer awareness of energy efficiency through labelling programs.[35] The GND also includes incentives and resources for green remodeling and the construction of energy-efficient facilities.

27. Various feebate schemes could complement existing measures by strengthening incentives for energy efficient and low carbon appliances and equipment. For example, sales of refrigerators, air conditioners, and other energy-consuming products could incur a fee given by:

$$\begin{aligned} &CO_2 \text{ price} \\ &\times CO_2 \text{ per unit of energy} \\ &\times \{\text{energy consumption per unit} - \text{industry-wide energy consumption per unit for the product}\} \\ &\times \text{number of units} \end{aligned}$$

For refrigerators, for example, the energy consumption unit would be kWh per cubic foot cooled (and the number of units would be cubic feet). A similar scheme applying taxes to gas- and oil-based heating systems, and a subsidy for electric heat pumps, could accelerate the transition to zero-carbon heating systems. Again, feebate schemes can avoid a fiscal cost; the carbon prices in feebate programs across different product categories are easily harmonized to promote cost effectiveness (under regulatory approaches there is no automatic mechanism for equating incremental mitigation costs across programs); and these schemes provide ongoing incentives to go beyond current standards.

Forestry

28. Ideally, forestry policies should cost-effectively promote, nationwide, the three channels for increasing forest carbon storage. These include: (i) afforestation; (ii) reducing deforestation; and (iii) enhanced management of tree farms (e.g., planting larger trees, longer rotations, fertilizing, tree thinning).[36] Expanding forest coverage generates other environmental co-benefits beyond carbon storage such as biodiversity preservation and reduced risks of water loss, floods, soil erosion, and river siltation.

29. A national feebate program could cost-effectively promote all responses for increasing carbon storage without a fiscal cost to the government. The policy would apply, to landowners, a fee given by:

$$\{CO_2 \text{ rental price}\}$$

[35] MOTIE (2015).

[36] Korea's updated NDC envisions projects to enhance the capacity of carbon sinks in the forestry sector but it lacks a mechanism to automatically, and cost-effectively, promote all such opportunities.

× {carbon storage on their land in a baseline year ─ stored carbon in the current year}

This scheme would reward all three channels for enhancing carbon storage, either through reduced fees or increased subsidies (unlike, for example, an afforestation subsidy which just rewards one channel). Feebates can be designed—through appropriate scaling of the baseline over time[37]—to be revenue-neutral in expected terms. Feebates should involve rental payments—on an annualized basis, a CO_2 price times the interest rate[38]—rather than large one-off payments for tree planting, given carbon storage may not be permanent (e.g., due to subsequent harvesting or loss through fires, pests, windstorms). While still rudimentary, forest carbon inventories are estimated through a combination of satellite monitoring, aerial photography, and on-the-ground tree sampling.[39]

D. Trade and International Perspectives

30. There is an active debate on trade and international coordination aspects of carbon mitigation and Korea—being a large industrialized country and a leader on the green transition—might usefully engage in this debate. The trade issue relates to the use of BCA, which the EU plans to introduce in 2023 and Canada, the U.K. and U.S. are currently considering.[40] The coordination issue relates to debate about an additional international mechanism to complement the Paris Agreement by scaling up action among key emitters in a multilateral way.

31. BCAs have three main rationales.[41] First, they help to alleviate the adverse impacts on industrial competitiveness from carbon-price-induced increases in energy prices, which can be critical for enhancing the political viability of carbon pricing. Second, they reduce the risk of 'emissions leakage', that is, partially offsetting increases in emissions in overseas countries induced by domestic mitigation policy.[42] Third, at an international level, they might encourage (through BCA exemptions for those with adequate pricing) stronger carbon pricing in other countries. The last rationale would have limited relevance for Korea, at least if Korea were acting unilaterally.

32. A BCA would impose charges for the embodied carbon in imports and, if the primary motivation is to address competitiveness and leakage concerns, it might be limited to products competing with EITE industries. These industries account for over 90 percent of emissions embodied in all Korea's manufacturing exports.[43] A BCA can be more effective at assisting

[37] See Parry (2020) for details.

[38] Periods might be defined as averages over multiple years given that carbon storage might be lumpy during years when harvesting occurs.

[39] See Mendelsohn and others (2012), Parry (2020) for further discussion of design issues for forestry feebates.

[40] For example, the U.S. Administration's Climate Plan contains a proposal for a BCA (see https://joebiden.com/climate-plan). Worldwide, only one BCA has been implemented to date, applying to the embodied carbon in imported electricity under California's ETS (e.g., Pauer 2018).

[41] For example, Morris (2018).

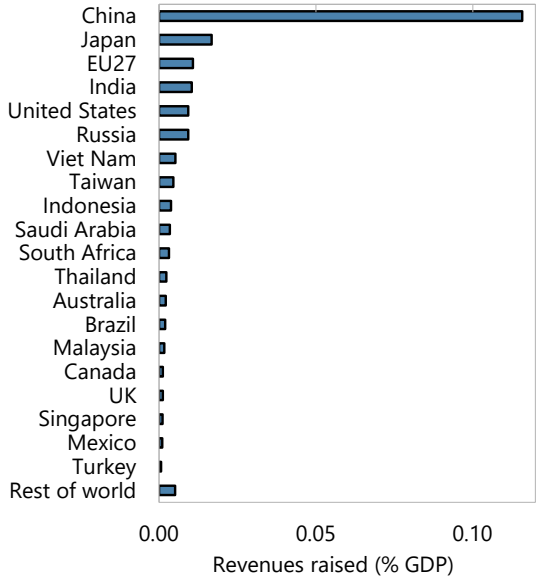
[42] One estimate suggests the leakage rate for carbon pricing in Korea (i.e., the increase in overseas emissions per unit reduction in domestic emissions induced by pricing) is 22 percent (IMF 2021, Ch. 2).

[43] OECD (2021).

EITE industries than free allowance allocation—under the latter the base of the compensation declines over time with deeper emissions reductions (Annex III). For illustration, a $50 BCA applied by Korea would have raised revenues of about 0.4 percent of GDP in 2015.

33. Concerns about BCAs revolve around administrative burdens and legal risks. A BCA would be administratively burdensome if it applied to imports of every product from every trading partner, but administration is much simpler if it is limited to EITE industries. Other design issues include whether to allow rebates for individual overseas exporters that are less carbon intensive than the industry average, how to adjust charges for carbon pricing or mitigation measures in trading partners, and whether to rebate charges for embodied carbon in exports—but all should be practical from an administrative perspective. Another concern about BCAs is the possibility of legal challenges at the World Trade Organization (WTO), or retaliation by trading partner. These legal risks are difficult to gauge ahead of time, but limiting the BCA to EITE industries might enhance the prospects for legality under trade law.[44] The authorities should consider whether a BCA might be an appropriate instrument for Korea, following early experiences with the prospective EU BCA, as an interim measure to more comprehensive international pricing—revenues from the BCA could help to fund Korea's clean energy transition.

Figure 11. Revenue from %50 BCA, 2015



Source: OECD (2021).

34. Although the 2015 Paris Agreement was a landmark achievement in international cooperation, an additional international mechanism is likely needed to stay on track with climate stabilization goals. The Paris Accord helped to galvanize the development of climate mitigation objectives at the country level and in some cases strong policies to implement these objectives. Even if all parties achieved their emissions pledges however, this would be cutting global emissions about 10 percent below projected levels for 2030 whereas emissions reductions of 28 percent and 55 percent would be consistent with a linear emissions pathway to 2°C and 1.5°C respectively.[45] One difficulty with the agreement is that there are many signatories (195) and targets are difficult to compare. Another difficulty is that countries acting unilaterally have limited incentives to scale up mitigation action due to concerns about competitiveness and free rider issues. A complementary international mechanism to the Paris Agreement should be effective, that is, contain a concrete plan to deliver the needed emissions reductions by 2030. And it should facilitate

[44] Reducing carbon leakage is a potential legal justification for trade measures like BCAs under GATT Article 20 (e.g., Flannery and others 2020).

[45] Updated from IMF (2019a).

negotiation, that is, it should be limited to a few key countries and a small number of transparent parameters.

35. One potential complementary mechanism is an international carbon price floor (ICPF) among large emitters. An agreement focused on China, the EU, India, and the US would cover nearly 70 percent of global emissions, or on the G20, would cover 80 percent of emissions. And focusing the agreement on a carbon price floor would have several key attractions: (i) this is an efficient and easily understood parameter; (ii) a simultaneous increase in effective carbon prices would help to address competitiveness and free rider concerns and avoid pressure for BCAs; (iii) the arrangement could be designed equitably, with stricter requirements for higher income countries and/or transparent technological or other assistance for lower income countries; and (iv) the arrangement might be designed flexibly to accommodate different approaches (e.g., ETSs, combinations of pricing, feebates, regulations) at the national level if they achieved equivalent emissions outcomes as would have been achieved by implementing the price floor. An ICPF could be highly effective in scaling up mitigation.[46] Korea might usefully contribute to international dialogue among large emitting countries on complementary mechanisms to the Paris Agreement.

E. Summary of Recommendations

- **Achieving Korea's goals of greening and de-carbonizing its economy will require further strengthening of the current policy framework**. This could be achieved through a comprehensive package of measures at the national (i.e., economy-wide) and sectoral level. Possible elements of such a package include:

- Aligning the trajectory of annual emissions caps with the 2030 emissions target.

- Underpinning the ETS with an exogenous and automatically rising floor price and ceiling.

- Transitioning to full auctioning of ETS allowances with revenues used to fund the clean energy transition and/or lower the burden of taxes on work effort.

- Replacing tax exemptions for EVs and HVs with a more comprehensive, revenue-neutral feebate to enhance incentives for low-emission vehicles;

- A feebate to reinforce incentives for shifting to carbon free power generation;

- Feebate schemes for the industrial sector to provide incentives for cleaner technologies with limited impacts on competitiveness and emissions leakage;

[46] For illustration, price floors of $75, $50, and $25 per ton respectively in 2030 for the three largest projected global emitters alone (the United States, China, and India) would be sufficient to keep G20 emissions in line with a 2°C target. See Parry (2020).

- Feebates to reinforce incentives for switching to carbon free space heating and more energy-efficient appliances and machinery;
- Considering whether a BCA might be an appropriate instrument for Korea, at some future point, perhaps after early experiences with an EU BCA.; and
- Contributing to multilateral dialogue on possible international arrangements among large emitters to complement and reinforce the Paris Agreement.

Table 3. Korea: Recommended Fiscal Instruments to Reinforce the Country's Mitigation Strategy

Sector	Instrument
Economy-wide	Align emissions caps in Phase 4 of the ETS with the 2030 emissions target; set an exogenous and progressively rising price floor underpinning the ETS; and transtion to full allowance actions. Auction revenues can be used for: (i) supporting the clean energy transition; (ii) lowering taxes on work effort and investment.
Power	Introduce feebate: a sliding scale of fees/rebates on generators with above/below average CO_2/kWh to complement the RPS and accelerate shifting to cleaner fuels, without a new tax burden on the average generator.
Road transport	Implement a fully comprehensive feebate for passenger vehicles: a sliding scale of fees/rebates applied to all vehicles with above/below average CO_2/km to build off existing fiscal incentives and complement emissions regulations. The feebate price can be set aggressively to promote EVs and HVs without a new tax burden on the average motorist or fiscal cost.
Industry	Introduce feebates: a sliding scale of fees/rebates on firms with emission rates above/below the industry average emission rate. Feebates can provide powerful incentives for cleaner production processes without a large tax burden on the average firm which lessens concerns about competitiveness and emissions leakage.
Buildings	Supplement energy efficiency regulations and building codes with: (i) a tax-subsidy scheme promoting shifting from natural gas/oil heating systems to electric or other clean fuel systems; (ii) feebates to promote more efficient appliances and lighting.
Forestry	Introduce a nationwide feebate applied to landowners equal to an (annualized) CO_2 price times the difference between forest carbon storage on their land in a baseline period and carbon storage in the current period. This promotes the full range of mitigation responses with no burden on the average landowner or fiscal cost to the government. Forest carbon inventories are monitored with satellite and aerial imagery and on the ground sampling.
Trade/international	Consider a BCA for EITE industries (in place of free allowance allocations) but also promote dialogue on a (far more effective) carbon price floor for scaling up action among large emitting countries.

References

APERC, 2019, *APEC Energy Demand and Supply Outlook* – 7th edition (Vol II). Asia Pacific Energy Research Centre Tokyo, The Institute of Energy Economics, Japan.

Arregui, N., C. Ebeke, J. Frie, D. Garcia-Macia, D. Iakova, A. Jobst, L. Rabier, J. Roaf, C. Ruo, A. Shabunina, and S. Weber, 2020, "EU Climate Change Mitigation: Sectoral Policies". EUR Departmental Paper, International Monetary Fund, Washington, DC.

Batini, Nicoletta and Philippe Pointereau, 2020, "Greening Food Supply in Advanced Economies." In *The Economics of Sustainable Food: Smart Policies for Health and the Planet*, N. Batini (ed.). Island Press and International Monetary Fund.

Bunch, David S., David L. Greene, Timothy Lipman, Dr. Elliot Martin and Dr. Susan Shaheen, 2011, *Potential Design, Implementation, and Benefits of a Feebate Program for New Passenger Vehicles in California*, pp. 59-61, prepared for the State of California Air Resources Board and the California Environmental Protection Agency.

Calder, Jack, 2015, "Administration of a U.S. Carbon Tax," In *Implementing a U.S. Carbon Tax: Challenges and Debates*, edited by I. Parry, A. Morris, and R. Williams (New York: Routledge).

CAT, 2020, *South Korea*. Climate Action Tracker. Available at: https://climateactiontracker.org/countries/south-korea.

Clements, Benedict, and David Coady, Stefania Fabrizio, Sanjeev Gupta, Trevor Alleyne, and Carlos Sdralevich, editors, 2013, *Energy Subsidy Reform: Lessons and Implications* (Washington: International Monetary Fund).

Climate Analytics, 2020, *Transitioning Towards a Zero-Carbon Society: Science-Based Emissions Reduction Pathways for South Korea under the Paris Agreement*. Berlin, Germany.

Coady, D., I. Parry, and B. Shang, 2018, "Energy Price Reform: Lessons for Policymakers." *Review of Environmental Economics and Policy* 12: 197-219.

Fischer, Carolyn, Richard Morgenstern and Nathan Richardson, 2015, "Carbon Taxes and Energy-Intensive Trade-Exposed Industries: Impacts and Options," In *Implementing a U.S. Carbon Tax: Challenges and Debates*, edited by I. Parry, A. Morris, and R. Williams. New York: Routledge.

Flachsland, Christian, Michael Pahle, Dallas Burtraw, Ottmar Edenhofer, Milan Elkerbout, Carolyn Fischer, Oliver Tietjen, and Lars Zetterberg, 2018, "Five Myths About a European Union Emissions Trading System Carbon Price Floor." Resources for the Future, Washington, DC.

Flannery, Brian P., Jennifer A. Hillman, Jan W. Mares, and Matthew C. Porterfield, 2020, *Framework Proposal for a US Upstream GHG Tax with WTO-Compliant Border Adjustments: 2020 Update*. Resources for the Future, Washington, DC.

Goulder, Lawrence H., Dallas Burtraw and Roberton C. Williams, 1999, "The Cost-Effectiveness of Alternative Instruments for Environmental Protection in a Second-Best Setting." *Journal of Public Economics*, Vol. 72, pp. 329-360.

Government of Korea, 2016, *Intended Nationally Determined Contribution*, available at: https://www4.unfccc.int/sites/submissions/indc/Submission%20Pages/submissions.aspx.

Government of Korea, 2019, *Second Climate Change Response Basic Plan*.

Government of Korea, 2020a, *Korean New Deal*.

Government of Korea, 2020b, *2050 Carbon Neutrality Promotion Strategy*.

ICAP, 2020a, *Korea Emissions Trading System*. International Carbon Action Partnership.

ICAP, 2020b, *EU Emissions Trading System*. International Carbon Action Partnership.

IEA, 2020, *Korea Balance 2017*. International Energy Agency, Paris, France.

IMF, 2019a, *Fiscal Monitor: How to Mitigate Climate Change*. International Monetary Fund, Washington, DC.

IMF, 2019b. *Fiscal Policies for Paris Climate Strategies—From Principle to Practice*. International Monetary Fund, Washington, DC.

IMF, 2021, *World Economic Outlook*, forthcoming International Monetary Fund, Washington, DC.

IPCC, 2019, *Climate Change and Land: An IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems*. International Panel on Climate Change, Geneva, Switzerland.

Mendelsohn, Robert, Roger Sedjo, and Brent Sohngen, 2012, "Forest Carbon Sequestration." In I. Parry, R. de Mooij, M. Keen (eds), *Fiscal Policy to Mitigate Climate Change: A Guide for Policymakers*, International Monetary Fund, Washington, DC.

Ministry of Economy and Finance, 2020, "Government Announces Overview of Korean New Deal". Press Release, July 14.

Morris, Adele, 2018, "Making Border Carbon Adjustments Work in Law and Practice." Tax Policy Center, Urban Institute and Brookings Institution, Washington, DC.

MOTIE, 2015, *Korea Energy Efficiency Policies: Korea's Energy Standards & Labeling.* Ministry of Trade, Industry and Energy.

MOTIE, 2017, *Announcement of the 8th Basic Electricity Supply and Demand Plan (2017-2031).* Ministry of Trade, Industry and Energy, Seoul.

MOTIE, 2019, *3rd Energy Master Plan.* Ministry of Trade, Energy and Industry, Seoul.

OECD, 2021, *Carbon Dioxide Emissions Embodied in International Trade*. Organisation for Economic Cooperation and Development, Paris.

OICA, 2019, *2018 Production Statistics*. International Organization of Motor Vehicle Manufactures.

Parry, Ian, 2004, "Are Emissions Permits Regressive?" *Journal of Environmental Economics and Management* 47: 364-387.

Parry, Ian W.H., 2019, "The Rationale for, and Design of, Forest Carbon Feebates." Unpublished manuscript, Washington: International Monetary Fund.

_____, 2020, "A Proposal for an International Carbon Price Floor Among Large Emitters." Unpublished note, International Monetary Fund, Washington, DC.

Parry, Ian and Roberton Williams, 2012, "Moving US Climate Policy Forward: Are Carbon Tax Shifts the Only Good Alternative?" In Robert Hahn and Alistair Ulph (eds.), *Climate Change and Common Sense: Essays in Honor of Tom Schelling*, Oxford University Press, 173-202.

Parry, Ian, Victor Mylonas and Nate Vernon, 2020, "Mitigation Policies for the Paris Agreement: An Assessment for G20 Countries." *Journal of the Association of Environment and Resource Economists*, forthcoming.

Parry, Ian, Dirk Heine, Shanjun Li, and Eliza Lis, 2014, Getting Energy Prices Right: From Principle to Practice. IMF, Washington DC.

Pauer, Stephan, 2018, "Including Electricity Imports in California's Cap-and-Trade Program: A Case Study of a Border Carbon Adjustment in Practice." *The Electricity Journal* 31: 39-45.

UNFCCC, 2020, *Greenhouse Gas Inventory Data*. United Nations Framework Convention on Climate Change, Bonn, Germany. Available at: https://di.unfccc.int/detailed_data_by_party.

van Ruijven, Bas J. Detlef, P. van Vuuren, Willem Boskaljon, Maarten L. Neelis, Deger Saygin, and Martin K. Patel, 2016, "Long-Term Model-Based Projections of Energy Use and CO2 Emissions from the Global Steel and Cement Industries." *Resources, Conservation, and Recycling* 112: 15-36.

Webb, M. and Kim, J., 2018. *Cracks in the Ice for South Korean Coal? The need for International Engagement to Support South Korea's Transition from Coal*. E3G, Solutions for Our Climate.