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Alternative Policies – Carbon Fees

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Carbon Fees

The AEO2020 Reference case generally assumes that existing laws and regulations remain as enacted throughout the projection period, including when the laws or policies are scheduled to sunset. However, in the area of policies that target emissions reduction, history has demonstrated that there is significant uncertainty in this assumption. To examine the effects of this uncertainty across the energy sector, EIA modeled three levels of economy-wide carbon fees. These fees apply only to CO₂ from energy combustion and do not include other gases such as methane.

Methodology

The three carbon fee cases start with fees of \$15, \$25, and \$35 per metric ton (mt) of CO₂ beginning in 2021. The fees rise by 5% per year in real 2019 dollars during the projection period, as shown in Table 1. Incorporating CO₂ fees increases the costs of certain forms of energy and reduces total consumer disposable income in the economy; returning revenues to consumers helps offset some of the loss in disposable income but does not completely mitigate it. EIA did not consider distributional effects within consumer segments in this analysis.

Table 1. Economy-wide carbon dioxide emissions prices in the AEO2020 carbon fee side cases (2019 dollars per metric ton of carbon dioxide)

Carbon fee case	Carbon fee in 2021	Carbon fee in 2050
\$15 Carbon Fee case	\$15.00	\$61.74
\$25 Carbon Fee case	\$25.00	\$102.90
\$35 Carbon Fee case	\$35.00	\$144.06

Source: U.S. Energy Information Administration, *Annual Energy Outlook 2020*

Results

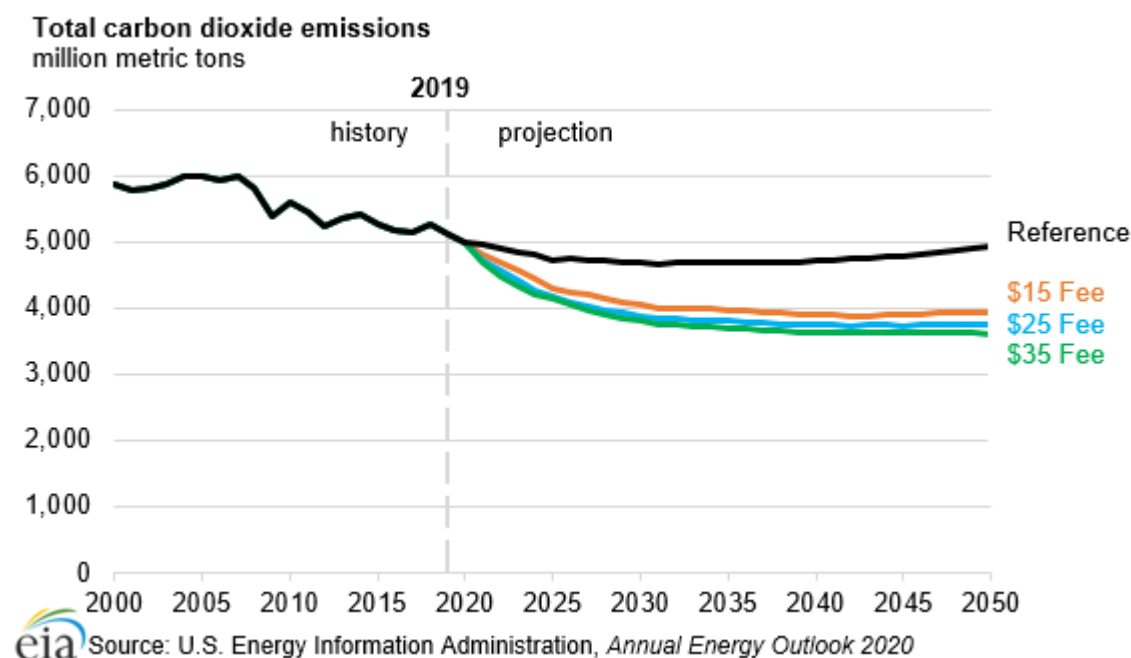
All three carbon cases show that energy-related CO₂ emissions decline before leveling off in the past 10 to 15 years. In all but the \$35 Fee case, emissions begin to rise at the end of the projection period despite increasing fees. Table 2 and Figure 1 show the allowance fees in selected years in real and nominal dollars, the resulting CO₂ emissions from combustion, and the incremental differences in annual emissions from the previous time period (e.g., five years before). These results vary across time, fuels, and sectors of the economy.

Table 2. Carbon fees, annual energy-related carbon dioxide emissions for selected years, and changes in annual emissions from previous time period for the Reference case and carbon fee cases

Cases	2020	2025	2030	2035	2040	2045	2050
Reference case							
Fee in 2019\$ per metric ton	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Fee in nominal dollars per metric ton	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Annual CO2 emissions (million metric tons)	4,993	4,733	4,674	4,691	4,715	4,782	4,922
Annual change from previous time (million metric tons)		-260	-59	18	24	67	140
\$15 Fee case							
Fee in 2019\$ per metric ton	\$0	\$18	\$23	\$30	\$38	\$48	\$62
Fee in nominal dollars per metric ton	\$0	\$21	\$31	\$44	\$62	\$89	\$128
Annual CO2 emissions (million metric tons)	5,004	4,302	4,037	3,968	3,902	3,895	3,932
Annual change from previous time (million metric tons)		-702	-264	-70	-66	-7	37
\$25 Fee case							
Fee in 2019\$ per metric ton	\$0	\$30	\$39	\$49	\$63	\$81	\$103
Fee in nominal dollars per metric ton	\$0	\$35	\$51	\$73	\$104	\$149	\$216
Annual CO2 emissions (million metric tons)	5,005	4,165	3,883	3,800	3,742	3,734	3,749
Annual change from previous time (million metric tons)		-839	-283	-83	-58	-8	14
\$35 Fee case							
Fee in 2019\$ per metric ton	\$0	\$43	\$54	\$69	\$88	\$113	\$144
Fee in nominal dollars per metric ton	\$0	\$50	\$72	\$103	\$147	\$211	\$305
Annual CO2 emissions (million metric tons)	5,005	4,132	3,804	3,693	3,636	3,617	3,610
Annual change from previous time (million metric tons)		-873	-328	-111	-57	-19	-7

Source: U.S. Energy Information Administration, *Annual Energy Outlook 2020*

Figure 1. Total carbon dioxide emissions for the Reference case and carbon fee cases



Fuels

Carbon fees affect fossil fuels and non-carbon-emitting alternative fuels differently. The factors that influence the response to the carbon fees include the carbon intensity of the fuel (CO₂/British thermal unit [Btu]), the efficiency and carbon intensity of the fuel's production, the demand response of the fuel to changes in the fuel's price, and whether substitute energy sources are readily available.

Coal

Coal is mainly used as an energy source in the electric power and industrial sectors. Coal is the most carbon-intensive fossil fuel with a typical intensity of about 95 kilograms of CO₂ per million Btu (kg CO₂/MMBtu) of energy consumed. In the electric power sector, coal competes directly with natural gas (the least carbon-intensive fossil fuel) and renewable generation. Because of its carbon intensity and ready availability of substitutes in the power sector, coal consumption decreases dramatically by 2025 in all carbon fee cases, and most of this decline occurs in the electric power sector. Most of the remaining coal consumption and related emissions after 2025 occur in the industrial sector where substitutes are not as readily available in certain industrial processes, which are therefore less sensitive to a CO₂ fee.

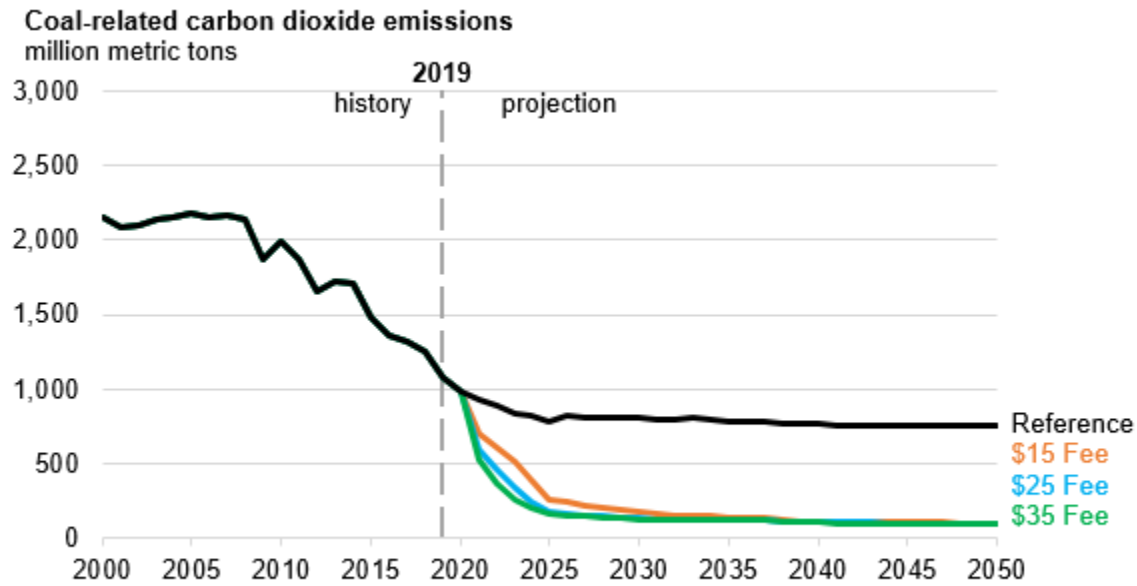
In the Reference case, many coal generating plants continue to operate under current policies, and coal-related CO₂ emissions in 2050 are more than seven times higher than in the carbon fee cases as shown in Figure 2.


Table 3. Changes in annual coal-related CO₂ emissions across selected years of the carbon fee cases

Cases	2020	2025	2030	2035	2040	2045	2050
\$15 Fee case							
Fee in 2019\$ per metric ton	\$0	\$18	\$23	\$30	\$38	\$48	\$62
Fee in nominal dollars per metric ton	\$0	\$21	\$31	\$44	\$62	\$89	\$128
Annual CO ₂ emissions (million metric tons)	982	257	183	143	115	105	102
Annual change from previous time (million metric tons)		-725	-74	-39	-28	-10	-3
\$25 Fee case							
Fee in 2019\$ per metric ton	\$0	\$30	\$39	\$49	\$63	\$81	\$103
Fee in nominal dollars per metric ton	\$0	\$35	\$51	\$73	\$104	\$149	\$216
Annual CO ₂ emissions (million metric tons)	982	178	135	122	107	103	100
Annual change from previous time (million metric tons)		-804	-43	-13	-15	-4	-3
\$35 Fee case							
Fee in 2019\$ per metric ton	\$0	\$43	\$54	\$69	\$88	\$113	\$144
Fee in nominal dollars per metric ton	\$0	\$50	\$72	\$103	\$147	\$211	\$305
Annual CO ₂ emissions (million metric tons)	982	165	131	120	105	101	98
Annual change from previous time (million metric tons)		-817	-35	-11	-15	-4	-4

Source: U.S. Energy Information Administration, *Annual Energy Outlook 2020*

Figure 2. Coal-related carbon dioxide emissions for the Reference case and carbon fee cases

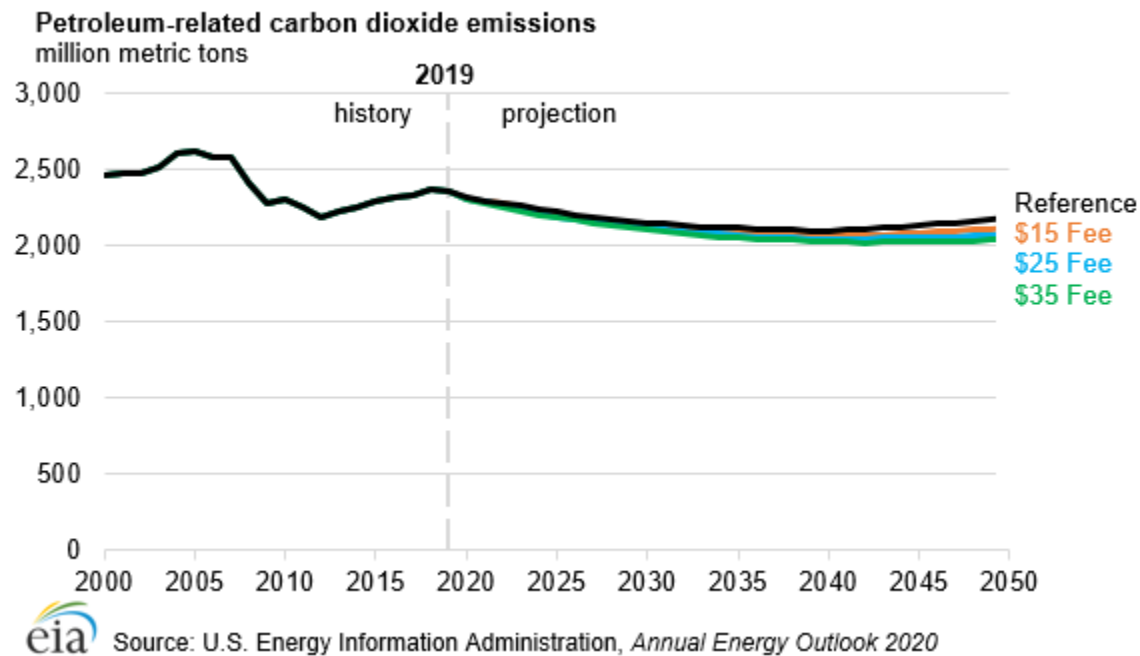


 Source: U.S. Energy Information Administration, *Annual Energy Outlook 2020*

Petroleum

Petroleum is an energy source used in all sectors of the U.S. economy, but it is most significantly used in the transportation and industrial sectors. The carbon intensity of the major petroleum products ranges from 70.9 kg CO₂/MMBtu for jet fuel to 78.8 kg CO₂/MMBtu for residual fuel oil, with motor gasoline at 71.3 kg CO₂/MMBtu. The difference in projected petroleum consumption between the Reference case and carbon fee cases is relatively small because, despite rising fuel prices, the opportunities for fuel substitutions in the transportation sector are limited during the projection period with the carbon fee levels examined. Demand for petroleum in certain industrial applications such as refining and bulk chemicals is also relatively price-insensitive. As a result, by 2050, the range between the Reference case and the \$35 Fee is 7% (145 million metric tons [MMmt]) (Figure 3).

Figure 3. Petroleum-related carbon dioxide emissions for the Reference case and carbon fee cases

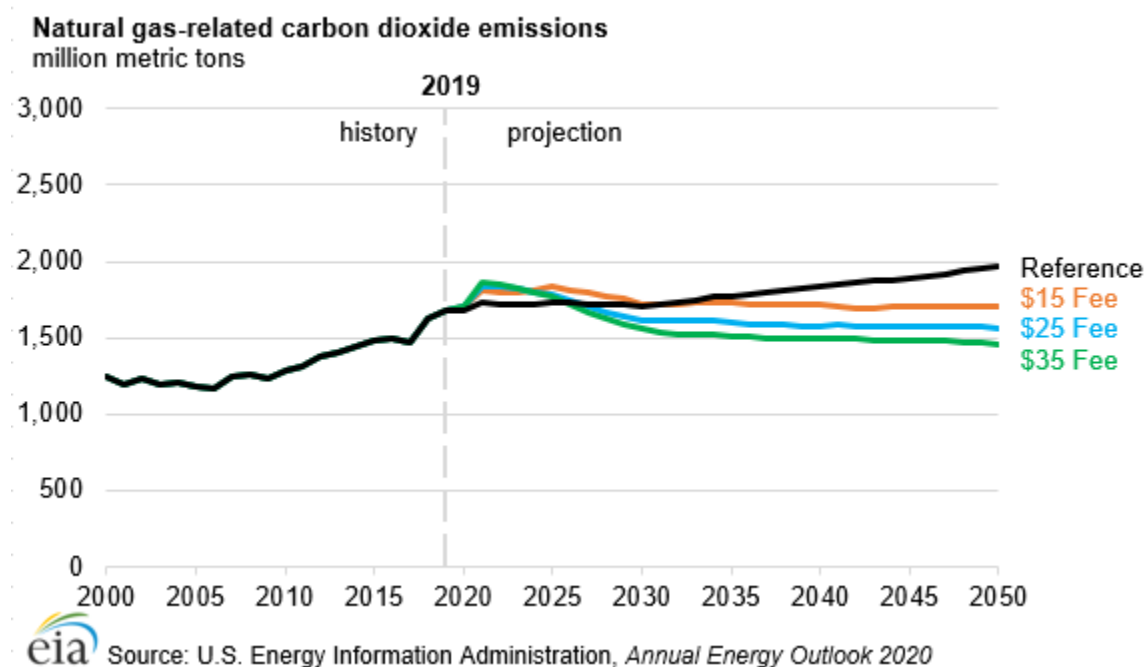


Natural gas

Natural gas has multiple uses in the U.S. energy economy, and more natural gas is consumed in the electric power sector than in the industrial sector. Natural gas is also an important fuel in the residential and commercial sectors primarily because of its use in space heating, water heating, and cooking. Because natural gas is the least carbon intensive of the fossil fuels (53 kg CO₂/MMBtu), it plays a unique role in response to carbon fees.

In the early stages of the projection period, natural gas-related CO₂ emissions exceed the Reference case in all of the carbon fee cases because natural gas-fired generation in the power sector, as with other lower-carbon intensive sources of generation, increases as coal-fired generation decreases. With the relatively low carbon fees associated with its emissions in these early years of the projection period, natural gas-fired generation continues to be economically competitive, and its associated emissions continue to grow. However, as the carbon fee increases over time, natural gas-fired generation and its associated emissions decrease, and the decrease varies with carbon fees across the three cases. After the mid-2030s, natural gas-related CO₂ emissions remain below the Reference case in all three carbon fee cases (Figure 4).

Figure 4. Natural gas-related carbon dioxide emissions for the Reference case and carbon fee cases



Energy sectors

Electric power sector

The electric power sector is an energy transformation sector that transforms primary energy into electrical energy that is sold to consumers in the end-use sectors. In the end-use sectors discussed below, EIA attributes electricity-related CO₂ emissions to each sector proportionally by electricity sales to that sector.

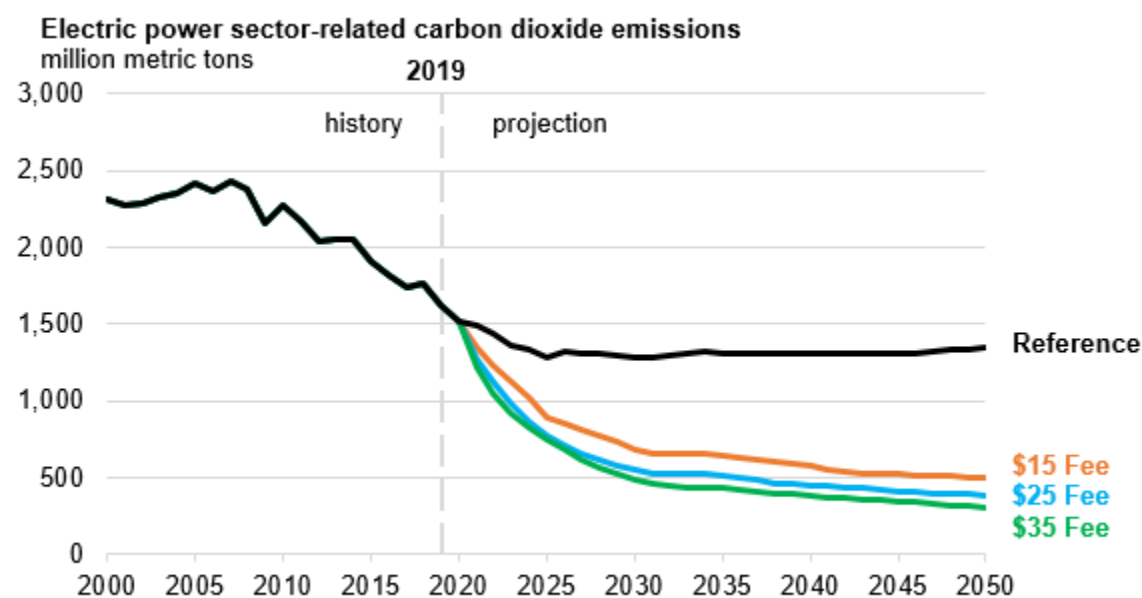
Fuel substitution is relatively easy in the electric power sector so coal is displaced by natural gas and renewables in the carbon fee cases. In addition, less nuclear power capacity is retired in the carbon fee cases. In the Reference case, 24 gigawatts (GW) of nuclear capacity are retired. In the \$15 Fee case, only 9 GW are retired and in both the \$25 Fee case and \$35 Fee case, only 8 GW are retired. Electric generation emissions that EIA attributes to the residential and commercial sectors (which depend most heavily on electricity) decline the most because coal is displaced by low-emitting natural gas and non-emitting renewables. Emissions attributed to the industrial sector decline less because the sector uses more petroleum and natural gas and because fewer opportunities exist for fuel switching. Emissions decline the least in the transportation sector because it consumes a relatively small amount of electricity and because the fees considered did not induce widespread growth in electric vehicles in the model.

The declining CO₂ emissions from the electric power sector continues its historical trend in which natural gas replaces coal in generation because it has become cost competitive. In addition, state-level renewable portfolio standards and federal tax incentives encourage renewable capacity growth, which further reduces coal generation. In the Reference case, this trend ends in 2025 as coal generation begins leveling off and emissions plateau thereafter. In contrast, in the carbon fee cases, coal-fired generation continues to retire as carbon fees increase fuel costs. Wind and solar generation increase to compensate

for the reduction in coal-fired generation. Wind generation increases 97% by 2050 from 2019 in the Reference case, compared with 214%, 228%, and 235% by 2050 in the \$15 Fee case, \$25 Fee case, and \$35 Fee case, respectively. Similarly, solar photovoltaic generation increases more than 800% by 2050 in the Reference case, compared with 1292%, 1340%, and 1387% by 2050 in the \$15 Fee case, \$25 Fee case, and \$35 Fee case, respectively.

Natural gas exhibits a relatively complex generation pattern in all three carbon fee cases. As coal-fired generation declines quickly after the imposition of a CO₂ fee, natural gas generation grows to compensate because logistical considerations limit the growth rate of new renewable generation capacity. As a result, while total U.S. energy-related emissions decrease throughout the projection period, CO₂ emissions from natural gas exceed those in the Reference case through 2025. In the \$35 Fee case, natural gas emission levels are lower than in the Reference case starting in 2026 and in the \$25 Fee case starting in 2027. In the \$15 Fee case, emission levels are not lower than the Reference case until 2031 (Figure 4).

Figure 5. Electric power sector carbon dioxide emissions for the Reference case and carbon fee cases

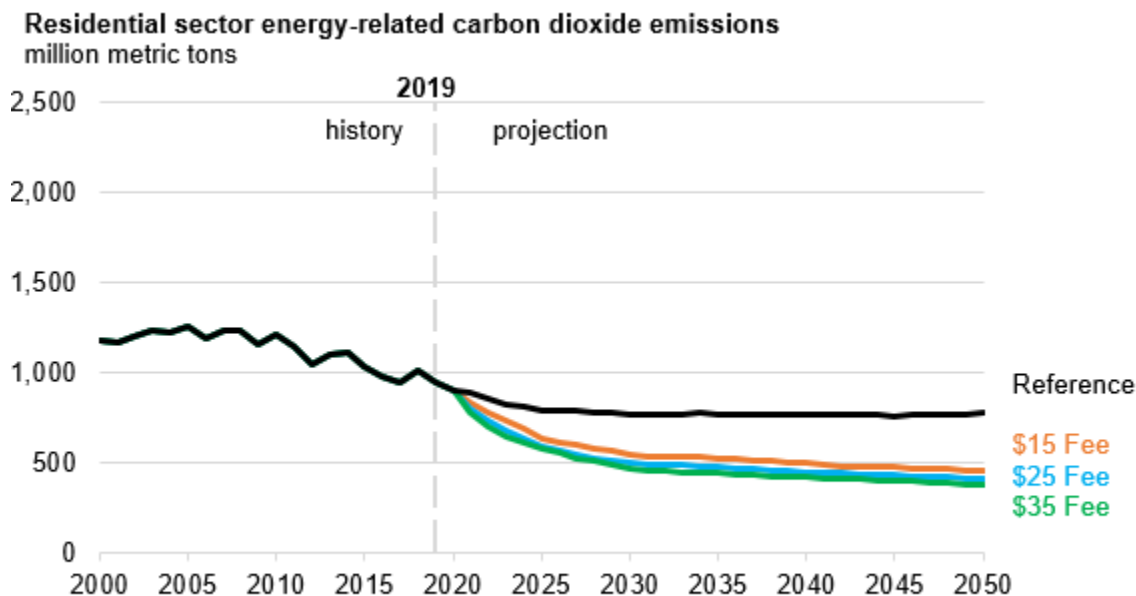


Source: U.S. Energy Information Administration, *Annual Energy Outlook 2020*

Residential sector

The U.S. residential sector consumed 4.9 quadrillion Btu of electricity in 2019, or 42% of its total delivered energy consumption. Uses include heating and cooling as well as water heating and refrigeration. Because of the residential sector's relatively large share of consumption of electric power, it exhibits a proportionally large response to the decline in coal-related emissions from electricity generation through the application of carbon fees. Of the 573 MMmt decline in energy-related CO₂ in the residential sector during the projection period in the \$35 Fee case, 87% is because of the reduction in carbon dioxide related to electricity purchased from the electric power sector. By 2050, CO₂ emissions in the \$35 Fee case are 51% lower than the Reference case (Figure 6).

Figure 6. Residential sector carbon dioxide emissions for the Reference case and carbon fee cases

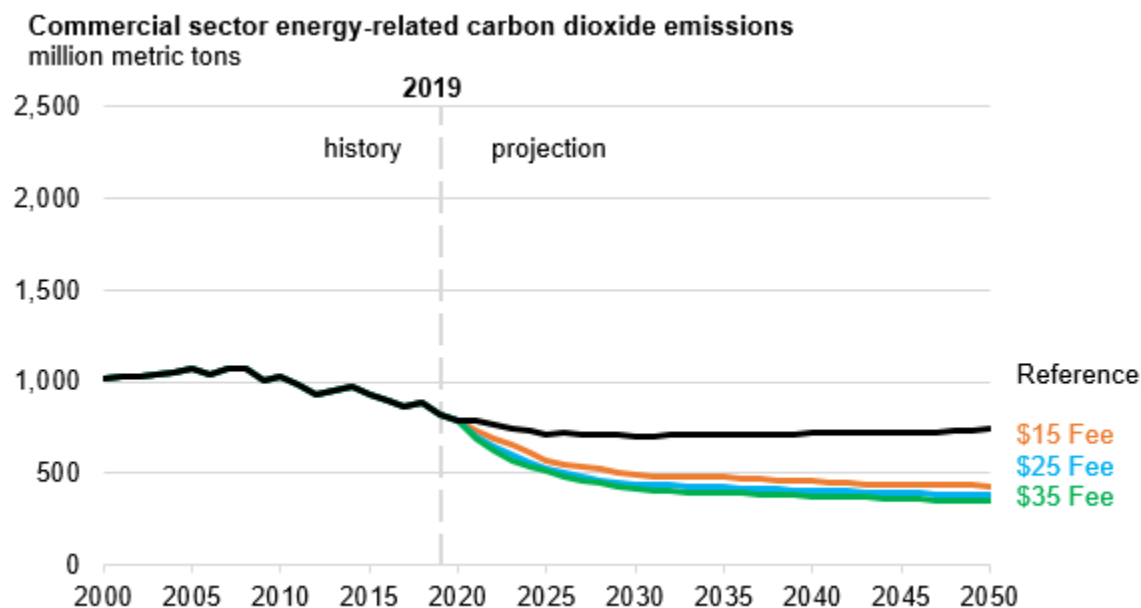


eia Source: U.S. Energy Information Administration, *Annual Energy Outlook 2020*

Commercial sector

The U.S. commercial sector relies on electricity for much of its energy, especially for lighting and refrigeration. As a result, 96% of the 477 MMmt commercial sector decline in CO2 emissions by 2050 in the \$35 Fee case is from the decline in electricity-related emissions. In addition, in the \$35 Fee case, CO2 emissions are 53% lower than the Reference case in 2050 (Figure 7).

Figure 7. Commercial sector carbon dioxide emissions for the Reference case and carbon fee cases



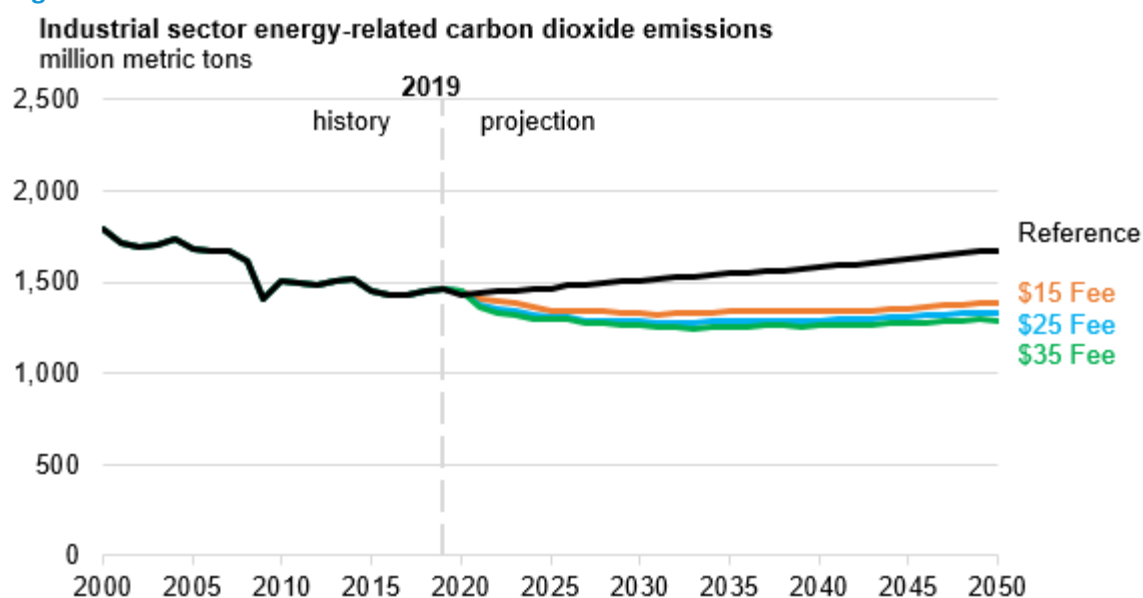
eia Source: U.S. Energy Information Administration, *Annual Energy Outlook 2020*

Industrial sector

The U.S. industrial sector is extremely heterogeneous and consumes a complex mix of fuels—many of them petroleum based. Natural gas is the predominant fuel and is mainly used for combined-heat-and-power generation. Electricity purchases play a relatively smaller role. Although emissions decline in the carbon fee cases relative to the Reference case (Figure 8), the difference is smaller than in the residential and commercial sectors, and emissions begin increasing after 2040 as gross output continues to rise with growing gross domestic product (GDP) assumptions.

The response to carbon fees varies by industry. For example, energy-intensive industries without readily substitutable alternative fuels, such as the bulk chemicals industry, show a relatively small reduction in CO₂ emissions with carbon fees. In the \$35 Fee case, there is a 29% increase in emissions from the bulk chemicals sector between 2019 and 2050, compared with a 53% increase during the same period in the Reference case.

Figure 8. Industrial sector carbon dioxide emissions for the Reference case and carbon fee cases

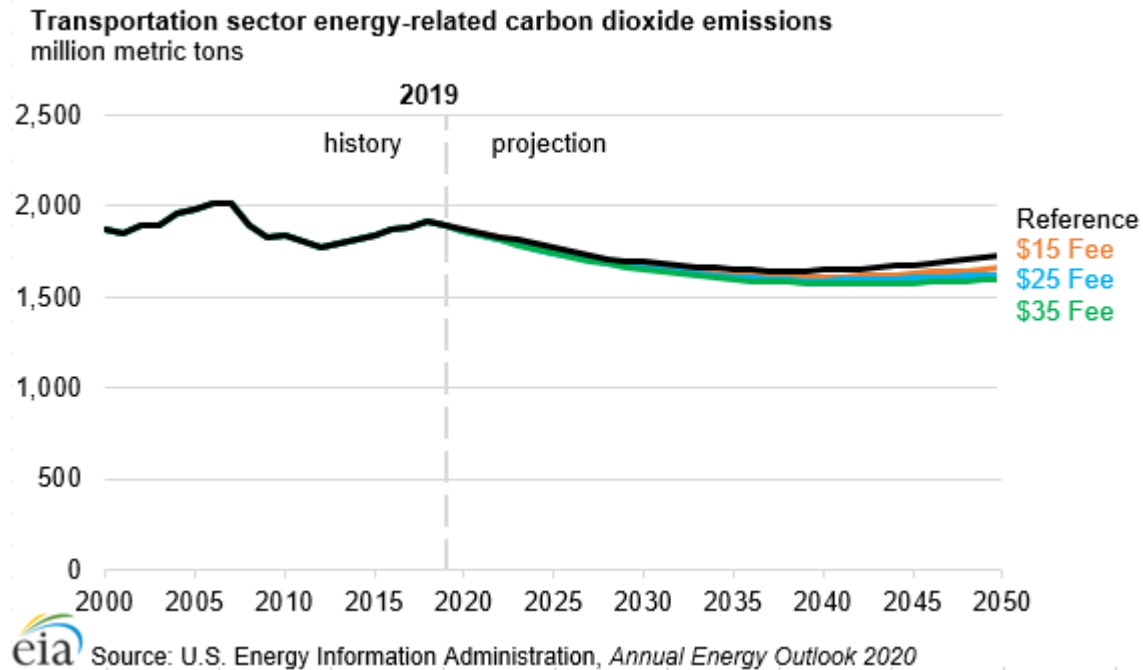


Source: U.S. Energy Information Administration, *Annual Energy Outlook 2020*

Transportation sector

Three modes of transportation account for 85% of the energy in the sector: light-duty vehicles (LDV) (15 quadrillion Btu in 2019), freight trucks (6 quadrillion Btu in 2019), and air travel (3 quadrillion Btu in 2019) in the Reference case. As indicated in Figure 9, by 2050, the difference in CO₂ emissions from the transportation sector between the Reference case and the \$35 Fee case is 136 MMmt of CO₂ (8%).

Figure 9. Transportation sector carbon dioxide emissions for the Reference case and carbon fee cases



LDV CO2 emissions decline 29% by 2050 in the \$35 Fee case, 7 percentage points more than in the Reference case. CO2 emissions from freight trucks decline 2% by 2050 in the Reference case and 11% in the \$35 Fee case. Air travel emissions increase by 36% from 2019 to 2050 in the Reference case. By comparison, air travel emissions still increase 33% by 2050 in the \$35 Fee case—illustrating the insensitivity of air travel-related CO2 emissions to a fee on those emissions.

Emissions from all other transportation fuels combined decline 1% in the Reference case and 6% in the \$35 Fee case. Even with 8% annual growth in electricity sales to the transportation sector during the projection period in the \$35 Fee case, petroleum remains the dominant transportation fuel at this level of carbon fee (

Table 4).

Table 4. Total change in carbon dioxide emissions by transportation type and case (2019–2050)

Types of transportation	Reference	\$15 Fee	\$25 Fee	\$35 Fee
Light-duty vehicles	-22%	-26%	-28%	-29%
Freight trucks	-2%	-6%	-9%	-11%
Air travel	36%	35%	34%	33%
All other	-1%	-4%	-5%	-6%
Total	-8%	-12%	-14%	-16%

Types of transportation	Reference	\$15 Fee	\$25 Fee	\$35 Fee
Light-duty Vehicles	-22%	-26%	-28%	-29%
Freight Trucks	-2%	-6%	-9%	-11%
Air Travel	36%	35%	34%	33%
All Other	-1%	-4%	-5%	-6%
Total	-8%	-12%	-14%	-16%

Source: U.S. Energy Information Administration, *Annual Energy Outlook 2020*

Prices

Electricity prices

In the Reference case, electricity prices (in real 2019 dollars) remain relatively stable and are slightly lower in 2050 than in 2020 (

Table 5). In the carbon fee cases, they rise until 2030 and remain relatively stable afterwards. In 2050, the average electricity price for all sectors is 12% higher than the Reference case in the \$15 Fee case, 17% higher in the \$25 Fee case, and 20% higher in the \$35 Fee case.

Table 5. Electricity prices by sectors and carbon fee cases
(cents per kilowatthour)

Case/sector	2020	2025	2030	2035	2040	2045	2050
Reference							
Residential	12.40	12.86	13.06	13.00	12.84	12.72	12.52
Commercial	10.31	10.39	10.38	10.18	9.98	9.83	9.65
Industrial	6.74	6.58	6.57	6.48	6.38	6.30	6.27
Transportation	11.57	12.33	12.52	12.48	12.15	11.83	11.53
Average to all sectors	10.21	10.32	10.37	10.26	10.13	10.03	9.90
\$15 Fee							
Residential	12.42	13.92	13.92	13.94	13.84	13.80	13.84
Commercial	10.33	11.37	11.17	11.06	10.83	10.73	10.69
Industrial	6.74	7.52	7.33	7.30	7.26	7.24	7.32
Transportation	11.59	13.28	13.39	13.43	13.34	13.23	13.14
Average to all sectors	10.22	11.32	11.18	11.16	11.07	11.04	11.08
\$25 Fee							
Residential	12.42	14.30	14.16	14.21	14.31	14.33	14.38
Commercial	10.33	11.73	11.38	11.22	11.23	11.21	11.22
Industrial	6.74	7.83	7.54	7.54	7.63	7.64	7.75
Transportation	11.59	13.65	13.66	13.94	13.86	13.78	13.67
Average to all sectors	10.22	11.67	11.40	11.39	11.49	11.52	11.60
\$35 Fee							
Residential	12.40	14.72	14.51	14.58	14.69	14.74	14.71
Commercial	10.31	12.11	11.69	11.55	11.60	11.62	11.52
Industrial	6.73	8.17	7.85	7.85	7.93	7.97	8.04
Transportation	11.57	14.04	14.05	14.31	14.28	14.12	13.97
Average to all sectors	10.21	12.06	11.73	11.74	11.86	11.92	11.91

Source: U.S. Energy Information Administration, *Annual Energy Outlook 2020*

Fossil fuel prices

The carbon fees have their greatest effect on coal prices (including fees), which are more than 700% higher in the \$35 fee case in 2050 (

Table 6). Prices are primarily affected by the carbon fee itself because the demand for coal is lowered in the carbon fee cases, which by itself could lower prices. The carbon fees have their second greatest effect on natural gas prices. Natural gas prices in the carbon fee cases are affected by a combination of the fee and the sustained demand for natural gas as coal consumption declines, especially in the early part of the projection period.

Table 6. Selected national average fossil fuel product prices by Reference and carbon fee cases (2019\$ per million British thermal units)

Case/Fuel	2020	2025	2030	2035	2040	2045	2050
Reference							
Motor Gasoline	22	22	23	25	26	27	29
Jet Fuel	14	15	17	18	19	21	22
Distillate	21	22	23	24	25	26	27
Natural gas	5	5	6	6	6	6	6
Coal	2	2	2	2	2	2	2
\$15 Fee							
Motor Gasoline	22	23	25	26	28	30	33
Jet Fuel	14	16	18	20	22	24	26
Distillate	21	23	24	26	28	30	32
Natural gas	5	6	7	7	8	8	9
Coal	2	4	4	5	6	7	9
\$25 Fee							
Motor Gasoline	22	24	26	28	30	32	36
Jet Fuel	14	17	19	21	24	27	29
Distillate	21	24	25	28	30	32	35
Natural gas	5	7	8	8	9	10	11
Coal	2	5	6	7	9	10	13
\$35 Fee							
Motor Gasoline	22	25	27	29	32	34	38
Jet Fuel	14	18	20	23	26	29	32
Distillate	21	25	26	29	31	35	38
Natural gas	5	8	8	9	10	12	13
Coal	2	6	8	9	11	14	17

Source: U.S. Energy Information Administration, *Annual Energy Outlook 2020*

Table 7 indicates the effect of carbon fees on the operating costs of coal and natural gas generators. The carbon fees increase the costs of all fossil fuel generation, but because natural gas is less carbon intensive than coal, it changes the competitiveness of coal versus natural gas in meeting electric load. In the Reference case, the operating cost of coal generators is less than that of natural gas combined-cycle generators after 2021. However, in the carbon fee cases, once the fee is imposed, the opposite occurs. The operating cost of natural gas generators is less than that of coal generators through the projection period. As soon as the carbon fee is imposed, the advantage in operating costs of natural gas generators versus coal generators contributes to the near-term switch from coal to natural gas generation. Eventually, natural gas loses share to renewable generation. Higher generation costs contribute to an increase in electricity prices as reflected in

Table 6.

Table 7. Effect of carbon fee on the operating costs for coal and gas generators

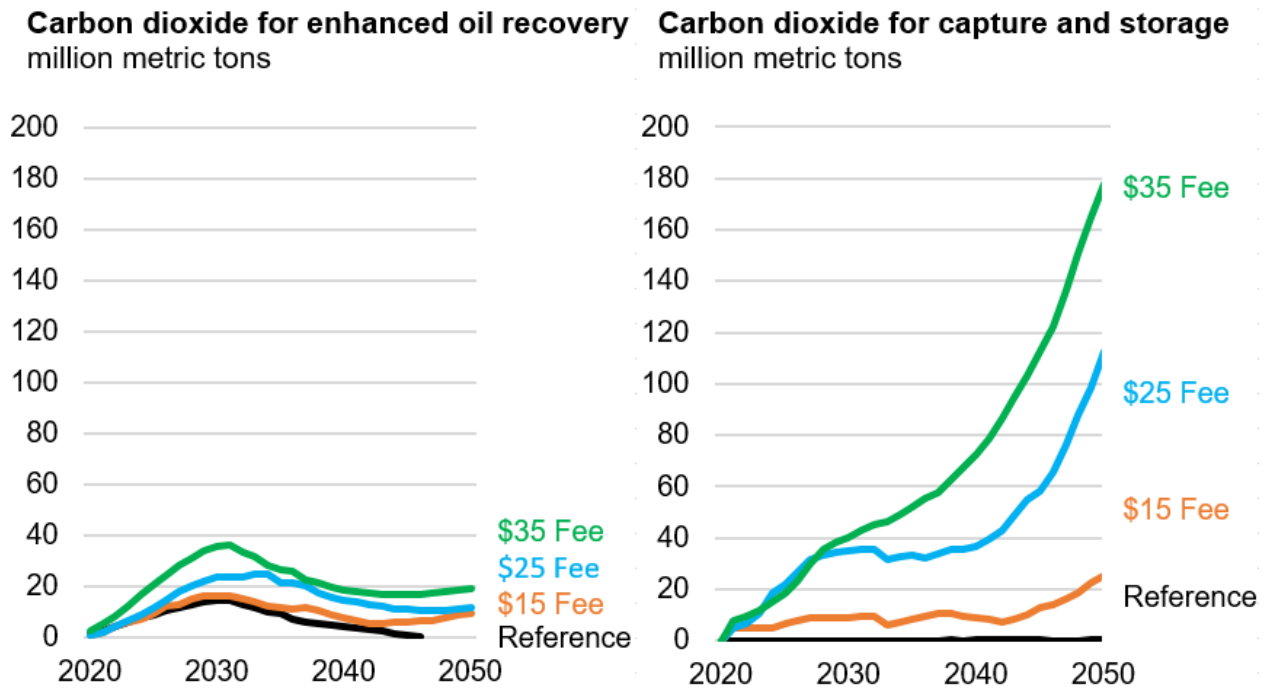
Case/fuel	2020	2021	2030	2040	2050
2019 dollars per megawatthour ¹					
Reference					
Gas	20.5	21.6	25.8	26.5	28.0
Coal	21.3	20.8	19.2	19.1	19.1
Difference	(0.7)	0.7	6.7	7.4	8.9
\$15 Fee					
Gas	20.7	29.6	34.5	39.2	48.9
Coal	21.4	35.4	41.4	59.2	93.9
Difference	(0.7)	(5.9)	(6.9)	(20.0)	(44.9)
\$25 Fee					
Gas	20.7	34.8	39.4	48.0	65.3
Coal	21.4	46.9	58.3	92.1	142.5
Difference	(0.7)	(12.1)	(18.9)	(44.1)	(77.2)
\$35 Fee					
Gas	20.7	38.9	44.6	58.1	82.0
Coal	21.4	56.9	74.9	123.4	189.9
Difference	(0.7)	(18.0)	(30.3)	(65.3)	(107.9)
(1) (delivered fuel cost in dollars per million British thermal units) x (average heat rate for coal and combined-cycle natural gas plants), excluding operations and maintenance costs					

Carbon capture, utilization, and storage

In the carbon fee cases, additional CO₂ is mitigated with carbon capture, utilization, and storage that removes CO₂ after combustion (Figure 10). The CO₂ is then liquefied and transported through pipelines to be used or stored. In the Reference case, 0.21 MMmt of CO₂ are captured in 2050. In the \$15 Fee case, \$25 Fee case, and \$35 Fee case, 26 MMmt of CO₂, 112 MMmt of CO₂, and 178 MMmt of CO₂ are captured annually by 2050, respectively.

In the Reference case, during the peak years in the early 2030s, about 15 MMmt of CO₂ used for enhanced oil recovery (EOR) comes from anthropogenic sources (caused by human activity rather than derived from natural sources)—about equal amounts from ethanol production and natural gas processing. Very little CO₂ for EOR comes from the electric power sector. Carbon fees cause this to change, with 36 MMmt of CO₂ coming from the power sector at the peak in 2031 in the \$35 Fee case, representing 84% of the total purchased anthropogenic CO₂ sources. In the Reference case, domestic oil production begins to plateau in the 2030s, and demand for CO₂ for EOR generally declines. However, in the fee cases, CO₂ for EOR from these sources rises as the fees rise.

Figure 10. The fee cases increase the amount of carbon dioxide captured, used, and stored

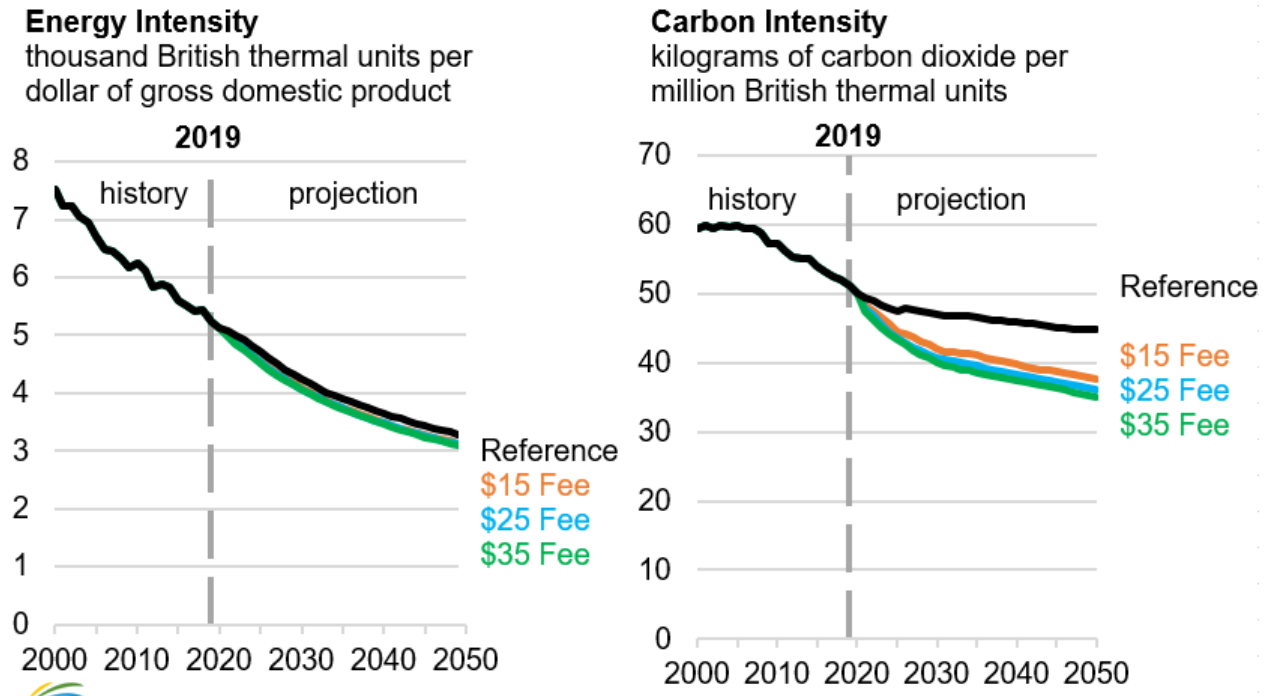


Source: U.S. Energy Information Administration, *Annual Energy Outlook 2020*

Energy and carbon intensity

Both the energy intensity and carbon intensity of the U.S. economy are affected by the carbon fees (Figure 11). The carbon intensity (kg CO₂/Btu) declines because the carbon fee encourages substitution of less carbon-intensive fuels in place of more carbon-intensive ones where possible. The energy intensity (Btu/GDP) declines because energy prices rise with carbon fees, reducing demand for energy products and causing increases in energy efficiency.

Figure 11. Energy and carbon intensity for all cases



Source: U.S. Energy Information Administration, *Annual Energy Outlook 2020*