



RESOURCES
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Greenhouse Gas Index for Products in 39 Industrial Sectors: Fossil Fuel Electric Power Generation

NAICS CODE 221112

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Important Note

This module is not a stand-alone document. Readers should refer to the introduction for a more detailed overview and discussion of the Framework and procedures to determine the GGI and, especially, to the ***Note on Common References, Default Values, Acronyms and Abbreviations used in the Modules***. Common information includes default values for CO₂ emissions from electricity and thermal energy derived from coal, oil and natural gas; a list of acronyms and abbreviations; guidance on using the sources cited for US exports, imports, and production by sector, and CO₂ emissions from electricity produced in nations that export to the United States.

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1. Introduction

NAICS Code 221112 comprises facilities primarily engaged in electric power generation powered by fossil fuels (such as coal, distillate fuel oil, or natural gas). They use these fuels in internal combustion or combustion turbine conventional steam processes to produce electric energy. According to the US Energy Information Administration (EIA),¹ during 2019, US exports of electricity to Canada and Mexico totaled about 20 million MWh, which amounted to about \$2.1 billion based on an average price of \$0.1054/kWh; US imports from Canada and Mexico were about 59 million MWh, which amounted to about \$6.2 billion. In the same year, US total sales of electricity were about \$401 billion.² Although these import and export numbers are small on an economy-wide basis, they are more significant regionally, especially along the Canadian border. Under the Framework we've proposed, the export rebates and import charges would be based on an upstream US greenhouse gas (GHG) tax and the GHG indices (GGIs) for the imported and exported products.³

Besides the application of GGI values to determine border tax adjustments for electricity, under the proposed Framework domestic industrial customers need to know the GGI values for electricity that they purchase to be able to determine the contribution from electricity to the GGI values of their products. In the United States, GGI values for electricity should be determined on a facility-by-facility basis. Electricity providers typically create dispatched supply from an entire portfolio of generating systems. Customers should use the average GGI value of electricity they purchase, as communicated by their provider, to determine its contribution to the GGIs of products that they manufacture. If a manufacturer obtains electricity under a contract that guarantees a particular source of electricity (e.g., from only renewable energy sources), it should use that value.

In this module, we determine indicative, representative GGIs—which track GHG process emissions and the contribution of the carbon content of products derived from fossil resources along the production and supply chain in a manner analogous to that used in value-added taxes—for electricity. When multiplied by the GHG tax, the result is the relevant export rebate or import charge. A minimum GGI of 0.25 tonnes CO₂e/MWh electricity is required for an export rebate or the imposition of an import charge. With this threshold, the electricity produced from fossil fuels would be a covered product eligible for export rebates and subject to import charges. We estimate that the GGI for electricity derived from bituminous coal is 1.05 tonnes CO₂e/MWh and that derived from natural gas is 0.46 tonnes CO₂e/MWh (note that

¹ https://www.eia.gov/electricity/annual/html/epa_02_14.html.

² https://www.eia.gov/electricity/annual/html/epa_01_01.html.

³ Flannery, Brian, Jennifer A. Hillman, Jan Mares, and Brian C. Porterfield. 2020. *Framework Proposal for a US Upstream GHG Tax with WTO-Compliant Border Adjustments: 2020 Update*. Washington, DC: Resources for the Future.

<https://www.rff.org/publications/reports/framework-proposal-us-upstream-ghg-tax-wto-compliant-border-adjustments-2020-update/>

these estimates are based on US average output and GHG emissions; values from individual facilities could differ significantly from these averages). If there were an upstream GHG tax of \$20 per tonne of CO₂, this would result in rebates of \$21.00 and \$9.20 per MWh, respectively.

As described in the Framework and the introduction to the modules, for electricity, $GGI = CO_2e(TOT)/MWh$. CO₂e(TOT) for electricity depends on the GGI of the fuel used to generate electricity and the technology used to convert thermal energy to electricity in the power plant. Because it takes energy with its related GHG emissions to produce fossil fuels, the GGIs for electricity will be larger than if they were determined solely by the carbon content of the fuel. Besides emissions associated with energy consumption, GGI values for fossil fuels are also affected, in some cases significantly, by GHG process emissions from the production and processing of fossil resources. Consequently, the GGI of electricity exceeds estimates based solely on the carbon content of the fuel, by amounts ranging from only a few percent to significantly more for some fuels. This module utilizes estimated GGI values of fuels presented in the modules for coal mining, crude petroleum and natural gas extractions, and petroleum refinery products. As well, throughout the modules, as a practical default standard, we make reference to Table 1 in the introduction of the modules that lists US average GHG emissions (tonnes CO₂/MWh) for electricity generation from coal, oil, and natural gas, as reported by EIA based on CO₂ from combustion of fuel.

This module provides a means for the Regulator to estimate, based on public information, initial export rebates for US exporters and import charges for US imports of electricity if there were an upstream GHG tax of \$20 per tonne of CO₂. This information would be useful to the Regulator in evaluating the information provided by exporters to indicate their requested export rebate.

Most producers of electricity are already obligated annually to determine and report their facility fuel consumption and CO₂ emissions to the EIA and Environmental Protection Agency (EPA). Thus, the firms in this sector will know the sources of energy used to generate their electricity production. Under the proposed Framework (see footnote 3), in the United States, fuel suppliers would communicate GGI values for covered products to their customers. So, electricity producers will have the information they need to determine GGI values for their electricity. More accurate and timely information to determine rebates and import charges could undoubtedly be obtained by the Regulator from either the industry association or firms (e.g., S&P Global, which has a business of obtaining and marketing information about the GHG aspects of various products).

The average GHG emissions from fuels used to manufacture electricity in the relevant country should be used to determine the CO₂ emissions from electricity use associated with production of the imported electricity—unless and until more specific,

verifiable information for the nation as a whole or for electricity exported by individual firms is provided to the Regulator.⁴

An important note: We emphasize that the estimates in this module are meant to provide only indicative, representative values for the GGIs of US electricity based on different energy sources. Some of the public data that the calculations rely on are dated and probably not representative of industry performance today. Actual values will depend on determination by electricity producers of the GGI for their electricity. Since companies, associations, and commercial firms that collect and market information about the energy and emissions profiles of electricity production can provide more accurate information than was used here, the Regulator should seek such information when determining potential import charges or evaluating requests for export rebates. The estimates here do not account for all GHG-intensive chemicals or other raw materials that may contribute to the GGI. Subject to the administrative costs to evaluate all such inputs and be consistent for both export rebates and import charges, the Regulator should strive to accept all verifiable raw material inputs to the GGI for specific products.

⁴ Such electricity information can be found in the International Energy Agency's *World Energy Balances 2020*; <https://www.iea.org/data-and-statistics/data-products?filter=balances%2Fstatistics>.

2. Electricity

The following estimates of GGIs for electricity produced in the United States from fossil fuels are based on data from the US EIA. In 2018, for the entire US electric system, it reports that average emissions (expressed as tonnes of CO₂ per MWh) were 1.00 for coal, 0.95 for oil, and 0.42 for natural gas (see Table 1 in the introduction to the modules). However, these estimates do not include additional contributions to the GGI of other sources of GHG emissions (i.e., those from along the supply chain to produce GHG-intensive products—in particular, those associated with extraction and initial processing of fossil resources to produce coal and natural gas, and those to produce and refine crude oil). In practice, suppliers of these products would communicate their actual GGI values to electricity producers. Here we supply indicative, representative estimates for the GGIs of electricity produced from fossil fuels.

We determine GGI values for electricity derived from fossil fuels by first utilizing results for GGI values required to produce fossil fuels and then considering the amount of fuel required to generate electricity for each of the various fuels. The modules that address the production of coal, petroleum and natural gas, and refined products provide the following GGI values for fossil fuels.

Table 1. Electric power generation GGI values by fuel type

Source	GGI tonnes CO ₂ e/ tonne of fuel	Source	GGI tonnes CO ₂ e/ tonne of fuel
Bituminous coal	2.68	Natural gas	3.06
Sub-bituminous coal	1.85	Distillate fuel oil	3.66
Lignite coal	1.52		
Anthracite coal	2.98		

These GGI values exceed those that would be obtained based solely on the fuel's carbon content because the production and processing of fossil fuels requires energy and may also result in GHG process emissions. Relative to their carbon content alone, these average GGI values are larger by (approximately) 1–5 percent for coal, 9 percent for natural gas, and 15 percent for distillate fuel oil. Values can vary significantly for specific producers. We note that estimates of methane leakage during the production of oil, gas, and coal remain controversial and could be significant in some cases. In any event, unless such methane emissions were covered as part of the upstream GHG tax,

they would not be included in estimates of the GGIs under our proposed Framework (see footnote 3).

Table 1 of the introduction to the modules listed US average values for CO₂ (not CO₂e) emissions from electricity generation as reported by the EIA. Here we estimate the GGI values for electricity, with units tonnes CO₂e per MWh, including not only the contribution to CO₂e(TOT) from the carbon content of the fuel, but also the additional contributions to CO₂e(TOT) from GHG process emissions and GHG-intensive products used to produce fossil resources and fuels. The accompanying modules for coal, natural gas and refined petroleum products provide relevant information for the fuels, including their carbon fraction, *cf*, by weight, GGI values and contributions to CO₂e(TOT). Sources cited include the EIA and EPA, as well as *cf* values for coal from the Climate Accountability Institute.⁵ We assume that the power plants themselves emit no GHG gases other than CO₂ from combustion of fuel and do not use electricity purchased from other suppliers. Information in the table below is based on the following:

Columns 1 and 2: Contributions to CO₂e(TOT) of electricity from carbon content of fuels:

Column 1: tonnes CO₂/MWh is from Table 1 of the introduction to the modules based on EIA data.

Column 2: tonnes fuel/MWh was derived using the following conversions:
$$t \text{ fuel/MWh} = (t \text{ CO}_2/\text{MWh}) (t \text{ carbon}/t \text{ CO}_2) (t \text{ fuel}/t \text{ carbon}) = (t \text{ CO}_2/\text{MWh}) (12/44)/cf,$$
where *cf* is the fraction of carbon by weight in the fuel.

Columns 3 and 4: Contributions to CO₂e(TOT) of electricity from GHG-intensive products purchased in the supply chain to produce fuels and GHG process emissions: CO₂e(SC+PE) tonnes CO₂e/tonne of fuel:

Column 3: CO₂e(SC+PE) tonnes CO₂e/tonne fuel, as reported in the modules for coal, natural gas, and petroleum refinery products based on US national averages.

Column 4: Converts from tonnes CO₂e per tonne of fuel to tonnes CO₂e per MWh as follows:
$$t \text{ CO}_2\text{e(SC+PE)}/\text{MWh} = (t \text{ CO}_2\text{e}/t \text{ fuel}) (t \text{ fuel}/\text{MWh}).$$

Column 5: GGI tonnes CO₂e/MWh including contributions to CO₂e(TOT) from column 1 (carbon content) and column 4 (supply chain and GHG process emissions).

⁵ <https://climateaccountability.org/pdf/Sums/Coal%20Sums/Coal%20CarbonCoefficient%208p.pdf>.

Table 2. Carbon content, emissions, and GGI by fuel type

Fuel	Carbon Content		Supply Chain & GHG Process Emissions		GGI t CO ₂ e/MWh
	t CO ₂ /MWh	t fuel/MWh	t CO ₂ e/t fuel	t CO ₂ e/MWh	
Bituminous coal	1.00	0.390	0.117	0.046	1.046
Sub-bituminous coal	1.00	0.545	0.020	0.011	1.011
Lignite	1.00	0.665	0.020	0.013	1.013
Anthracite	1.00	0.350	0.117	0.041	1.041
Natural gas	0.42	0.151	0.258	0.039	0.459
Distillate fuel oil	0.95	0.298	0.477	0.143	1.093

As described above, the increases in GGI of electricity relative to a value based solely on the carbon content of the fuel (values in column 4 relative to those in column 1) are approximately 1-5 percent for coal, 9 percent for natural gas, and 15 percent for distillate fuel oil. However, these ratios can vary considerably depending on the fuels and technology of particular power plants.

3. Export Rebates

If there were an upstream GHG tax of \$20 per tonne of CO₂, the export rebates for electricity based on the GGIs above would be as follows.

Table 3. Export rebated for electricity by fuel type

Fuel Source	GGI tonnes CO ₂ e/MWh	Export Rebate \$/MWh
Bituminous coal	1.05	21.00
Lignite & Sub-bituminous coal	1.01	20.20
Distillate fuel oil	1.09	21.80
Natural gas	0.46	9.20

4. Import Charges

According to Climate Transparency, Canada’s electricity is predominantly derived from renewable sources.⁶ In 2018, 8 percent of Canadian electricity was generated from coal, 1 percent from oil, and 9 percent from natural gas. The Regulator could provide import charges for electricity based on the three fossil fuels and require the importer to declare the source or sources used and thereby determine the import charge. Until importers provide the Regulator the source or sources used for their electricity based on credible, verifiable information, the Regulator could assume that coal was used for the imported electricity. Similarly, until importers provide credible, verifiable information to support and claim a lower GGI for their electricity generation facilities, the Regulator should use the GGIs for the average US coal-, oil-, or natural gas-based facility.

Based on the table above, if there were a GHG tax of \$20 per tonne of CO₂, the initial import charge for electricity from Canada would be as follows.

Table 4. Initial import charge for electricity from Canada by fuel type

Fuel Source	GGI tonnes CO ₂ e/MWh	Import Charge \$/MWh
Bituminous coal	1.05	21.00
Lignite & Sub-bituminous coal	1.01	20.20
Distillate fuel oil	1.09	21.80
Natural gas	0.46	9.20

According to the Statista, in 2021, Mexico’s electricity was 54 percent based on natural gas, 5 percent on coal, 10 percent on oil, with the balance provided by renewable and nuclear.⁷ The Regulator could provide import charges for electricity based on the three fuels and require importers to provide the source used, and thereby determine the import charge. Until importers provided the Regulator with credible, verifiable information, the Regulator could assume that coal was used for the imported electricity. Similarly, until importers provide credible, verifiable information to support and claim a lower GGI for their electricity generation facilities, the Regulator should use the GGIs for the average US coal-, oil-, or natural gas-based facility.

⁶ See: <https://www.climate-transparency.org/wp-content/uploads/2020/11/Canada-CT-2020.pdf#page=6>.

⁷ See: <https://www.statista.com/statistics/1237496/mexico-distribution-of-electricity-production-by-source/>

Based on what's above, if there were a GHG tax of \$20 per tonne of CO₂, the initial import charge for electricity from Mexico would be as follows.

Table 5. Initial import charge for electricity from Mexico by fuel type

Fuel Source	GGI tonnes CO ₂ e/MWh	Import Charge \$/MWh
Bituminous coal	1.05	21.00
Lignite & Sub-bituminous coal	1.01	20.20
Distillate fuel oil	1.09	21.80
Natural gas	0.46	9.20

