NORTH AMERICAN GHG EMISSIONS

JANUARY 2025

INTRODUCTION

Environmental, Social, and Governance or ESG factors are increasingly becoming more material to business risk and growth opportunities. Reducing emissions are a large part of ‘E’ in ESG.

This analysis will review overall worldwide emissions and forecast US and Canadian emissions for the oil, natural gas, and electric generation sectors.

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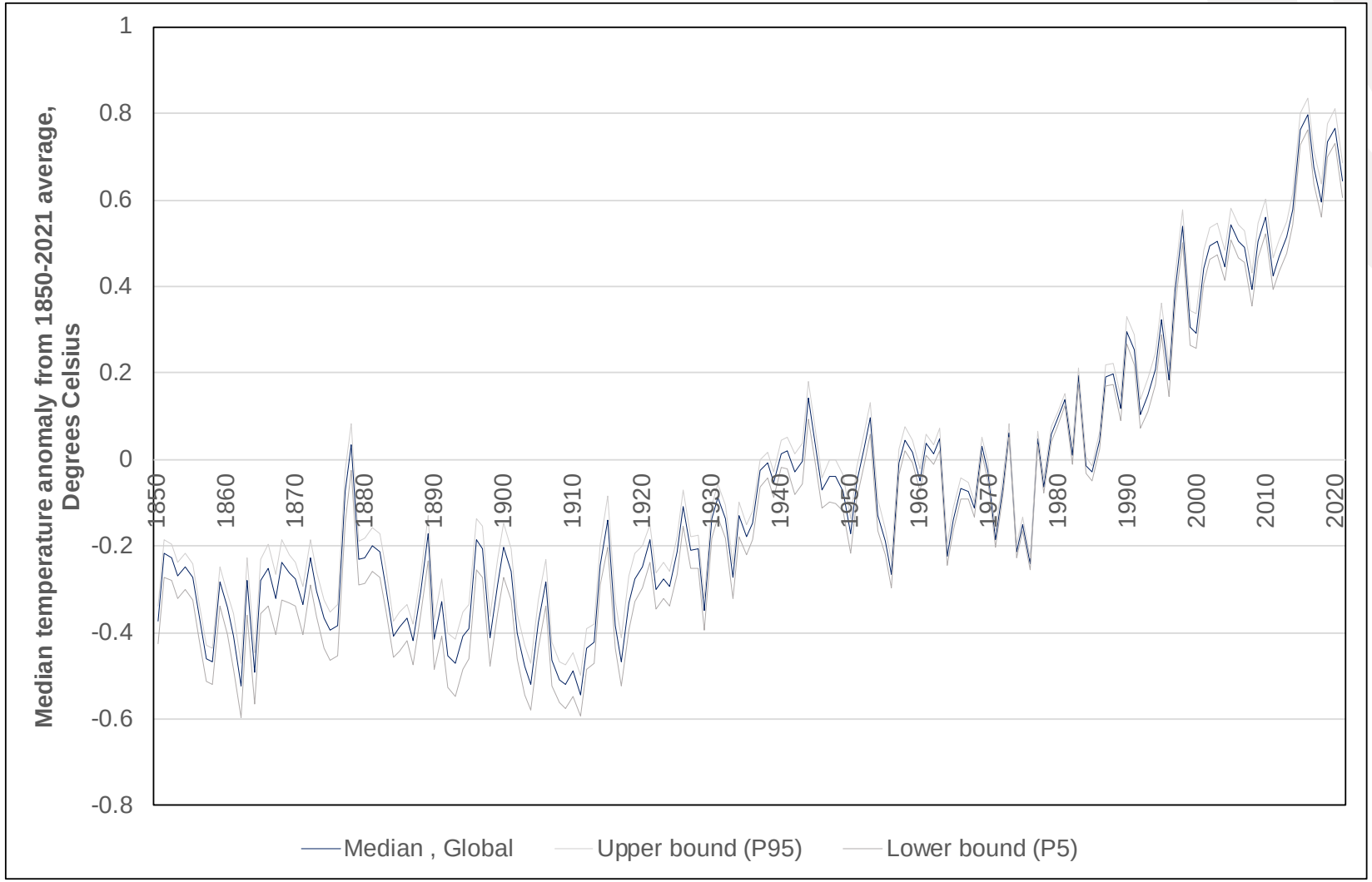
GLOBAL TEMPERATURE GROWTH



The blue line represents the average annual temperature trend through time, with upper and lower confidence intervals shown in light grey.

In 2015-2021 global average temperature was 0.71 degrees Celsius greater than in average temperature in 1961 – 1990.

Source:

Morice, C. P., J. J. Kennedy, N. A. Rayner, and P. D. Jones (2012), Quantifying uncertainties in global and regional temperature change using an ensemble of observational estimates: The HadCRUT4 dataset, J. Geophys. Res., 117, D08101, doi:10.1029/2011JD017187.

Morice, C.P., J.J. Kennedy, N.A. Rayner, P.D. Jones (2011), Quantifying uncertainties in global and regional temperature change using an ensemble of observational estimates: the HadCRUT4 dataset, Journal of Geophysical Research, accepted

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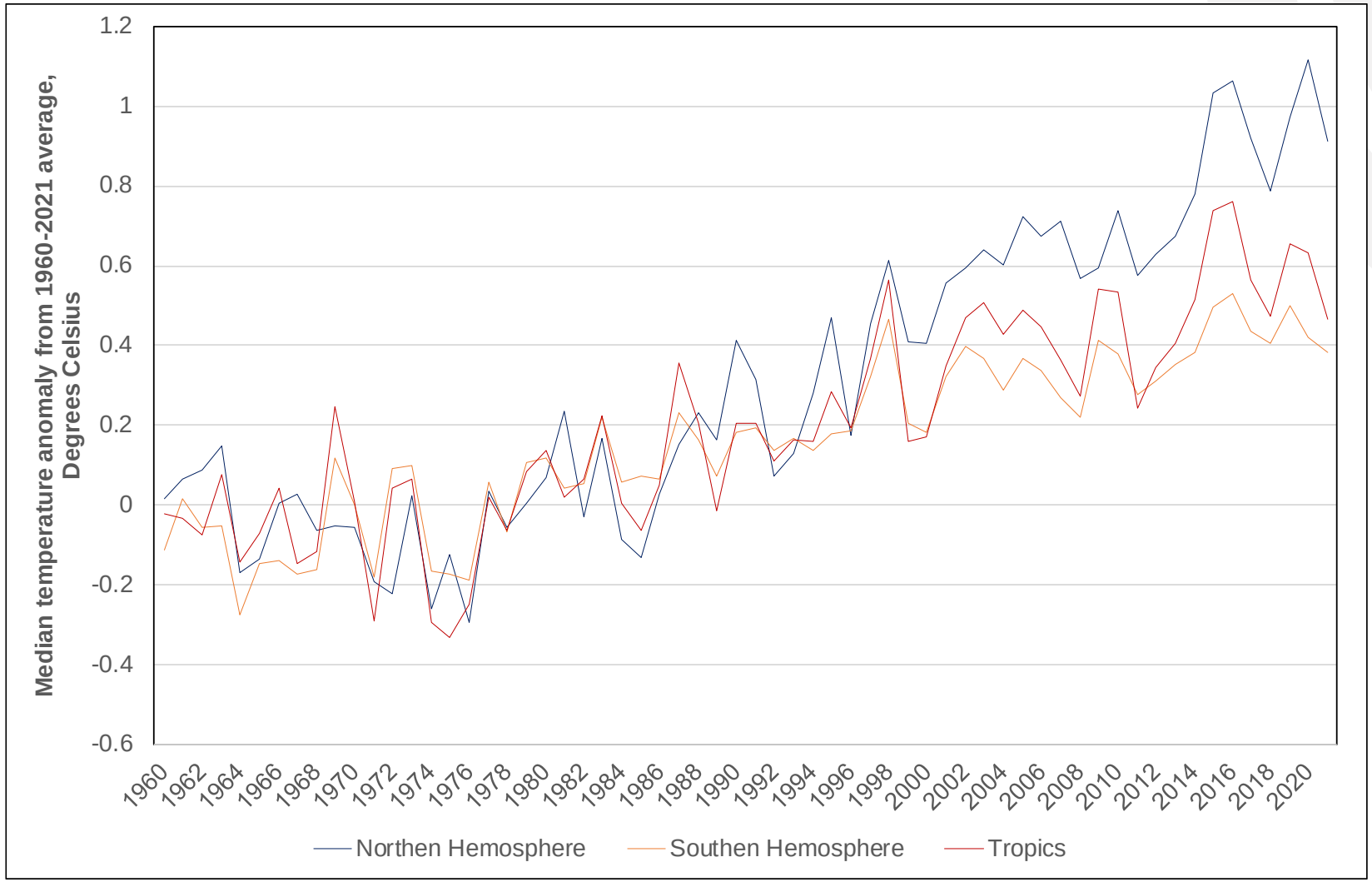
GLOBAL TEMPERATURE GROWTH PER PEGION



Northern Hemisphere had most significant temperature increase

In 2015-2021 global average temperature in Northern Hemisphere was 0.97 degrees Celsius greater than in average temperature in 1961 – 1990 compared with 0.61 in Tropics.

Source:

Morice, C. P., J. J. Kennedy, N. A. Rayner, and P. D. Jones (2012), Quantifying uncertainties in global and regional temperature change using an ensemble of observational estimates: The HadCRUT4 dataset, J. Geophys. Res., 117, D08101, doi:10.1029/2011JD017187.

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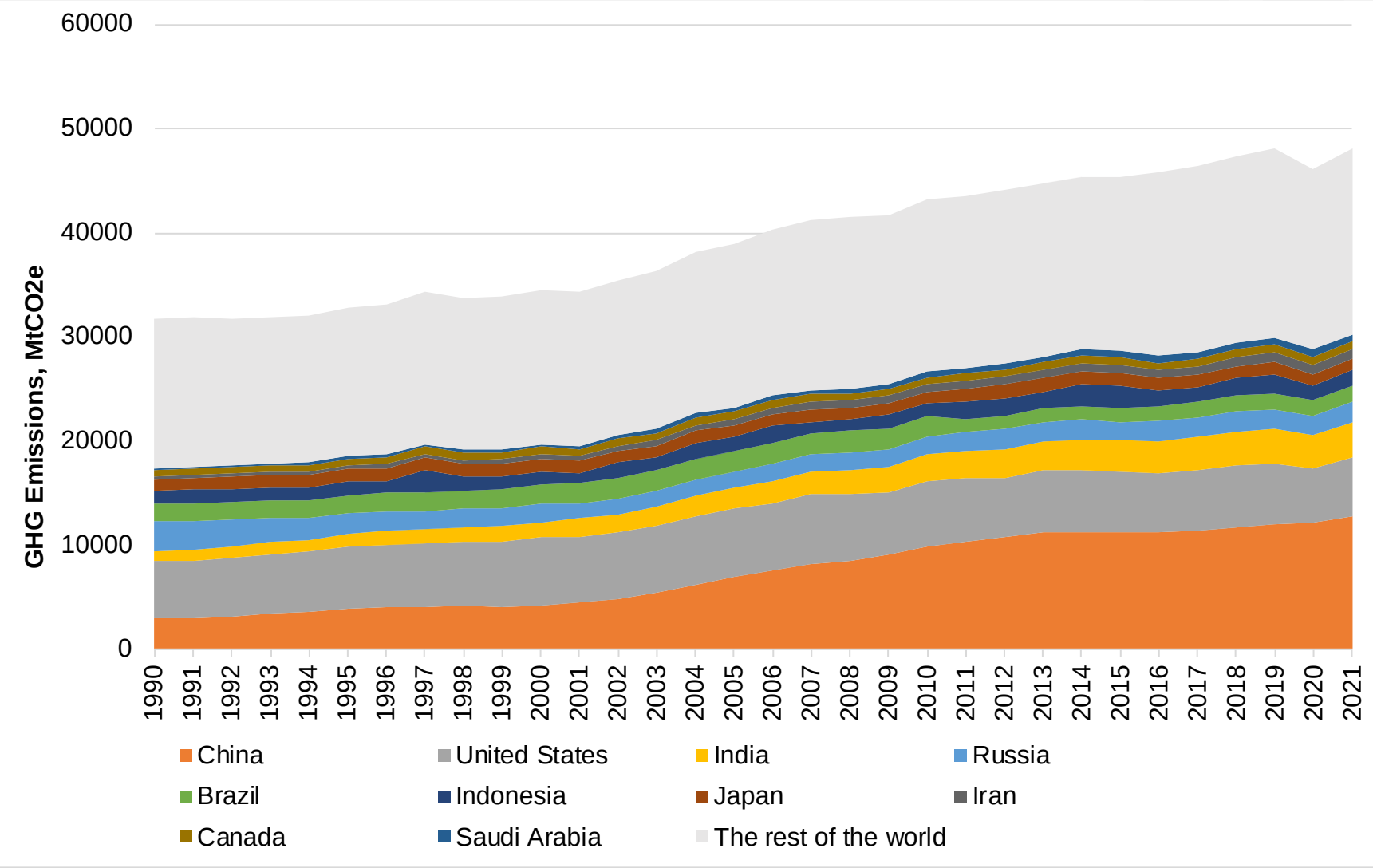
GLOBAL HISTORICAL GHG EMISSIONS PER COUNTRY



Between 1990 and 2021, Global Green House Gas (GHG) emissions increased 51% to 48,100 Mt of CO2 equivalent, up from 31,800 Mt of Mt CO2e in 1990.

Over the same time period, Chinese CO2e increased 345%.

In the US, GHG emissions peaked in 2004 and have since fallen to 5,500 Mt of CO2 in 2021 – resulting in 0.5% growth compared to 1990.

Source:

CAIT Climate Data Explorer
https://www.climatewatchdata.org/ghg-emissions

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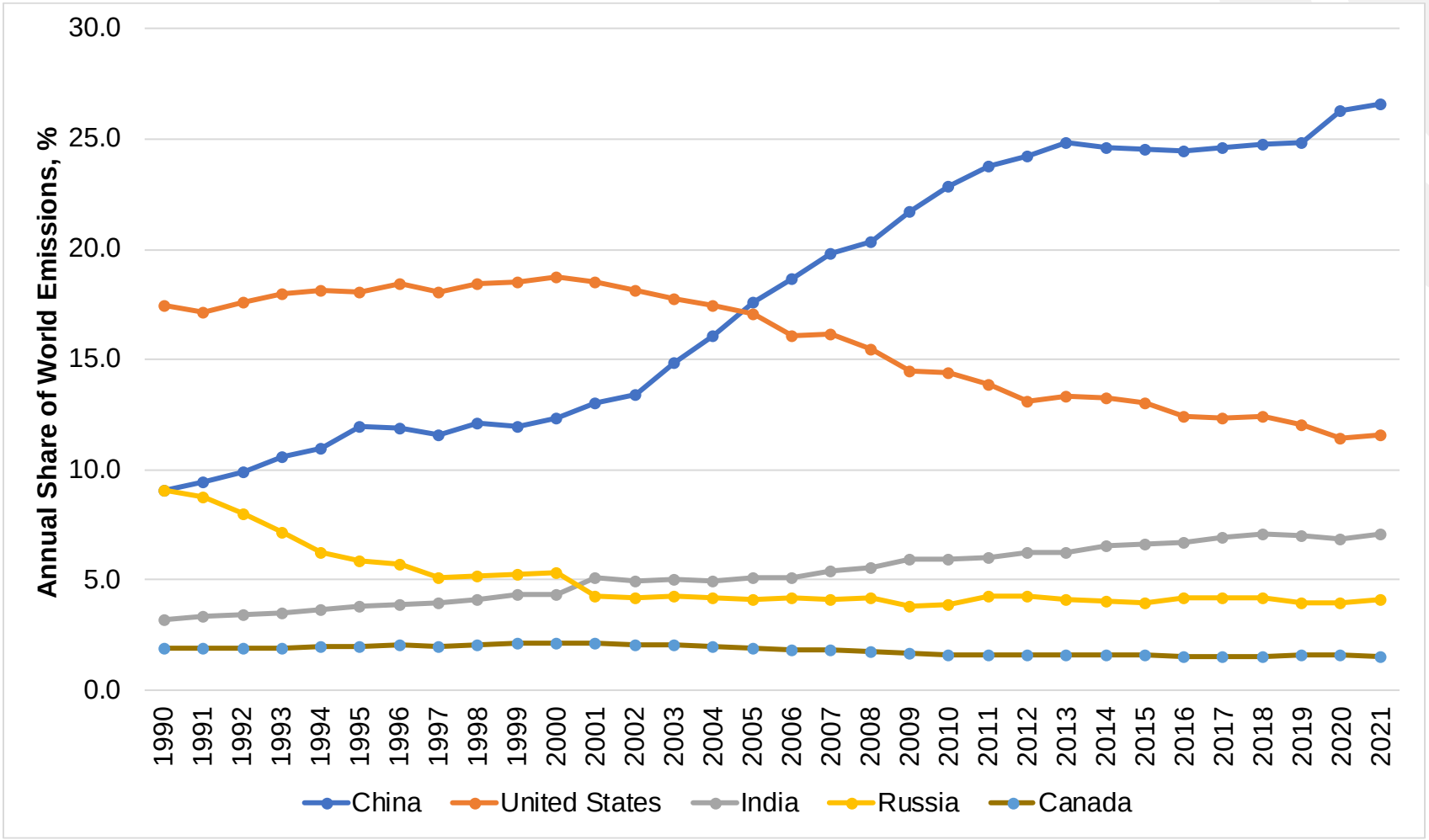
ANNUAL SHARE OF WORLD GHG EMISSIONS



In 2005 China surpassed the US to become worlds largest emitter of GHG and since then has doubled the US in overall share with almost 26% of global emissions while US emits 11%.

Share of emissions from India has increased to 7% in 2021 up from 3% in 1990.

Canadian emissions dropped to 1.5% of global GHG emission in 2021 down from 1.9% in 1990.

Source:

CAIT Climate Data Explorer
https://www.climatewatchdata.org/ghg-emissions

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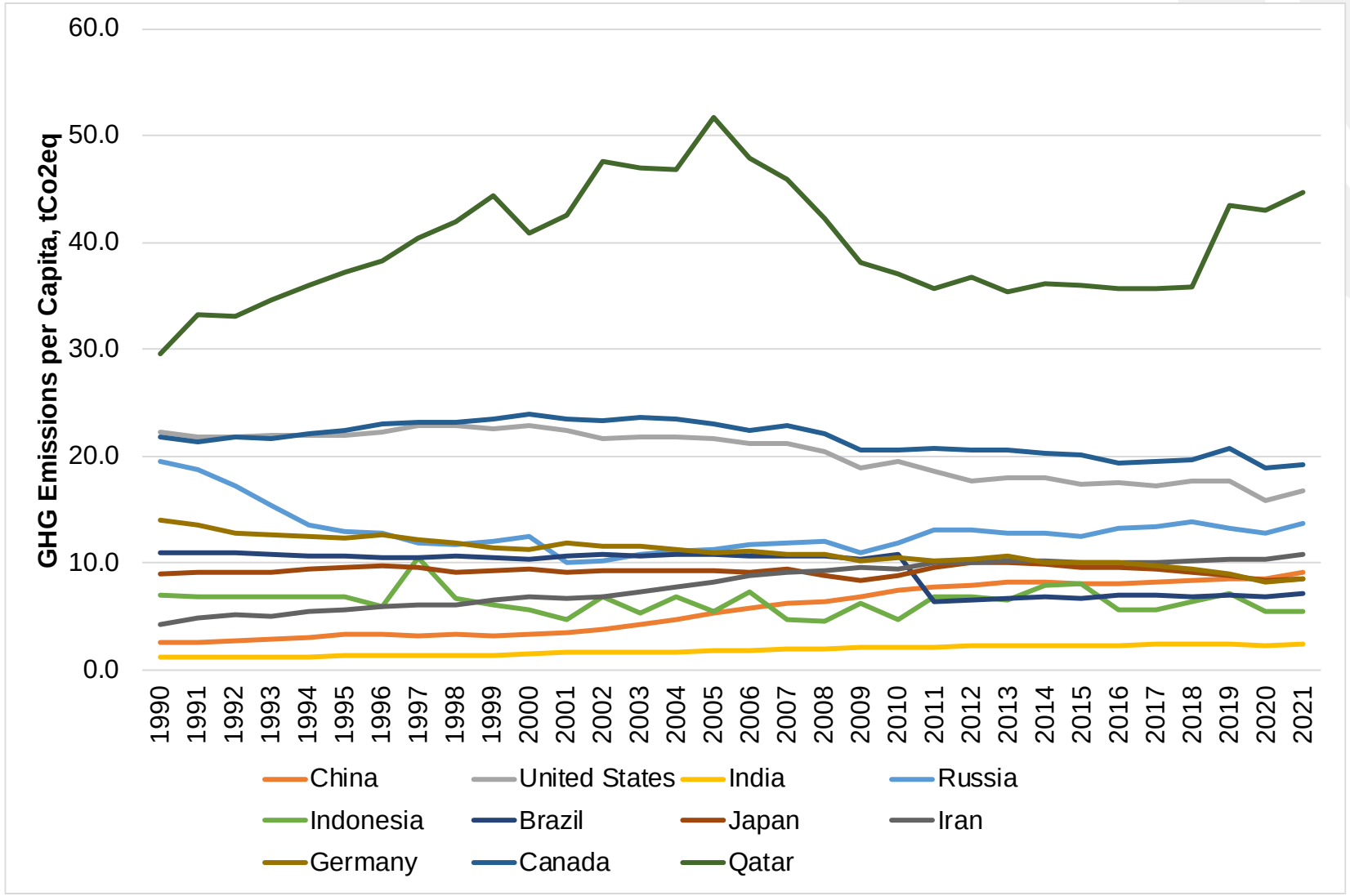
PER CAPITA GHG EMISSIONS



The chart shows GHG emissions per capita for 10 largest emitters.

In 2021 Qatar has largest GHG emissions of 44 tCO2eq per capita despite moderate total GHG emissions of 100 Mt CO2 eq.

China GHG emissions per capita was 9.1 tCO2eq in 2021 while US emissions was 16.8 tCO2eq.

Differences in heating and cooling requirements due to country location can influence per capita intensity.

Source:

CAIT Climate Data
https://www.climatewatchdata.org/ghg-emissions

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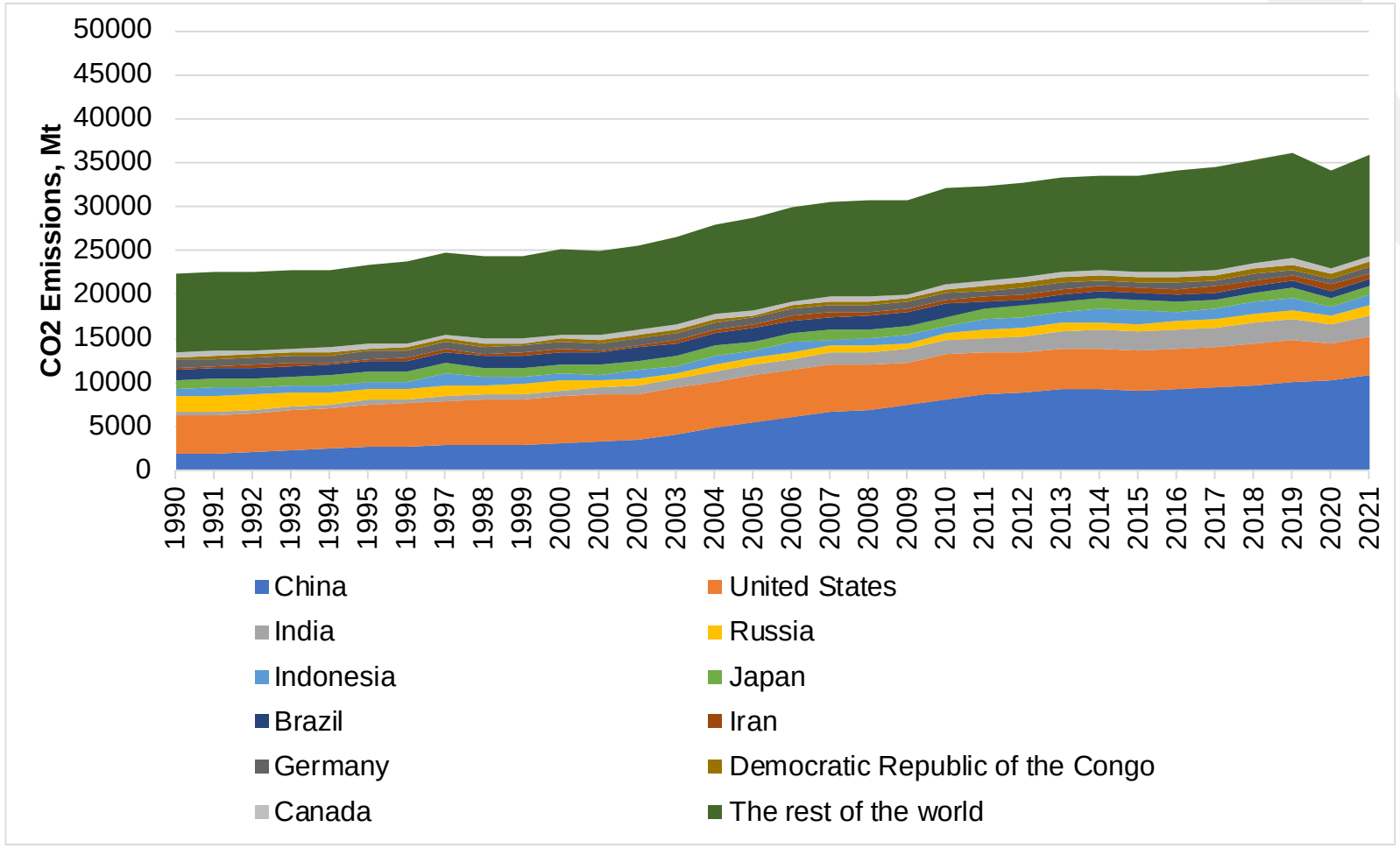
GLOBAL HISTORICAL CO_2 EMISSIONS PER COUNTRY



CO_2 represented 73% of global GHG emissions in 2021. World CO_2 emissions increased 61% from 1990 to 2021 and reached 35,400 Mt.

China is the largest emitter of CO_2 with 10,900 Mt emissions in 2021 followed by US with 4,400 Mt.

Source:

CAIT Climate Data
https://www.climatewatchdata.org/ghg-emissions

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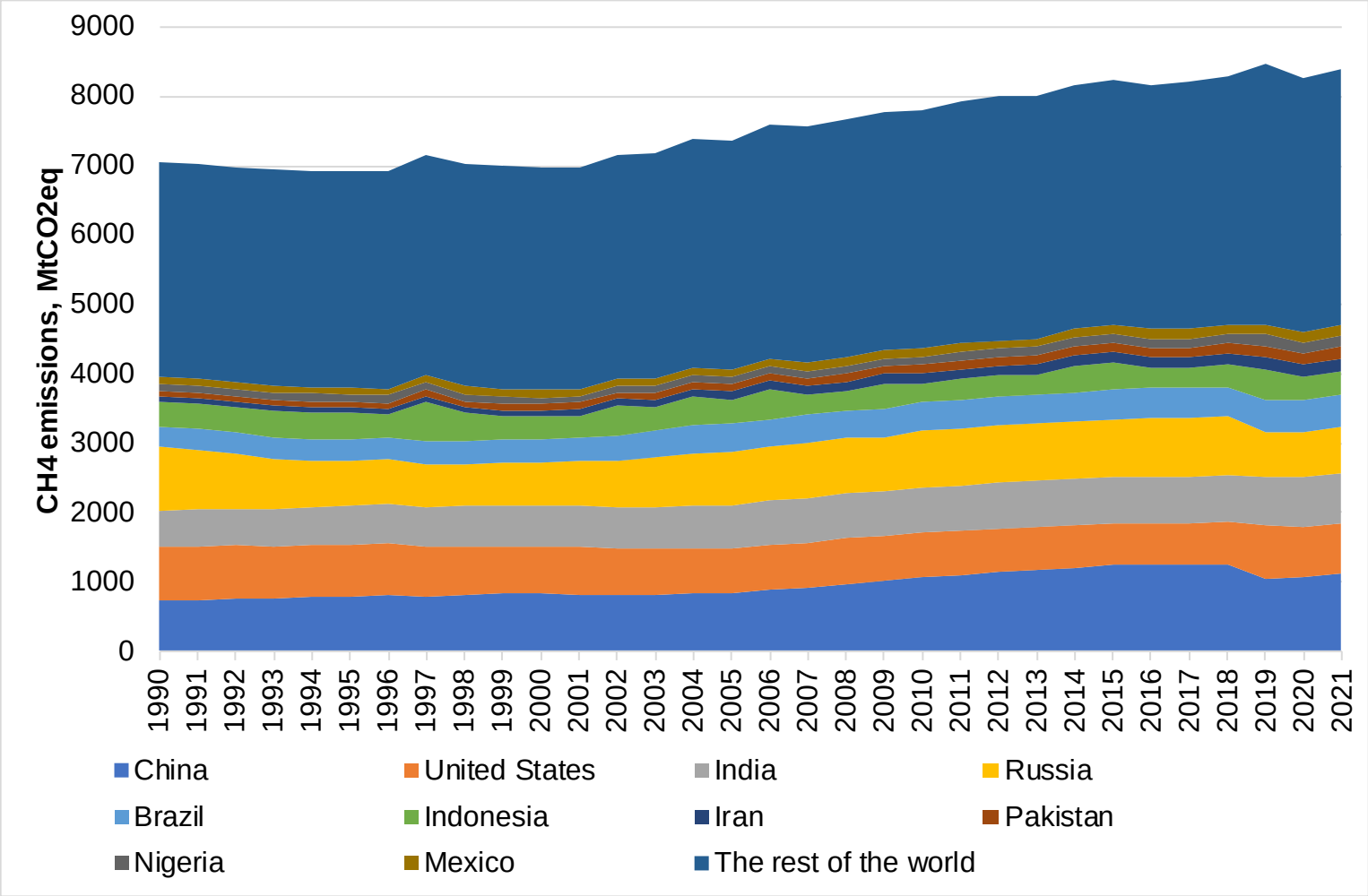
GLOBAL HISTORICAL METHANE EMISSIONS PER COUNTRY



Methane (CH4) represented 18% of global GHG emissions in 2021. World CH4 emissions increased 19% from 1990 to 2021 and reached 8,400 Mt.

China is the largest emitter of CH4 with 1,100 Mt emissions in 2021 followed by US with 730 Mt.

Source:

CAIT Climate Data Explorer
https://www.climatewatchdata.org/ghg-emissions

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US HISTORICAL GHG EMISSIONS

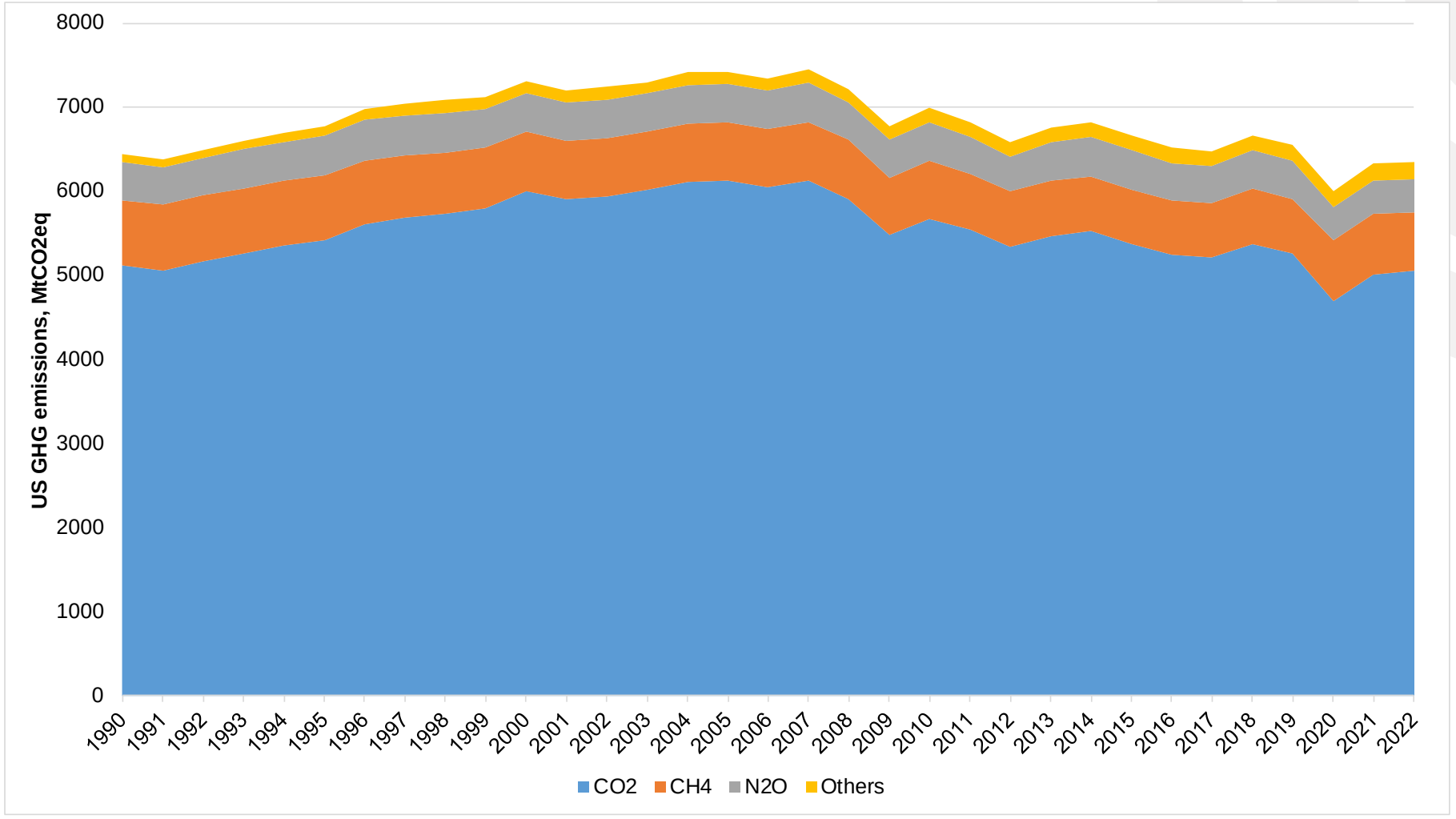

Chart shows total US emissions without Land Use, Land-Use Change, and Forestry (LULUCF) emissions and sinks.

In 2022, total gross U.S. greenhouse gas emissions were 6,300 MtCO2eq. U.S. emissions have decreased by 1.5 percent from 1990 to 2022, down from a high of 15.6 percent above 1990 levels in 2007.

Source:

EPA. 2022. Inventory of Green House Gas Emissions and Sinks. https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2022

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US HISTORICAL CO_2 EMISSIONS

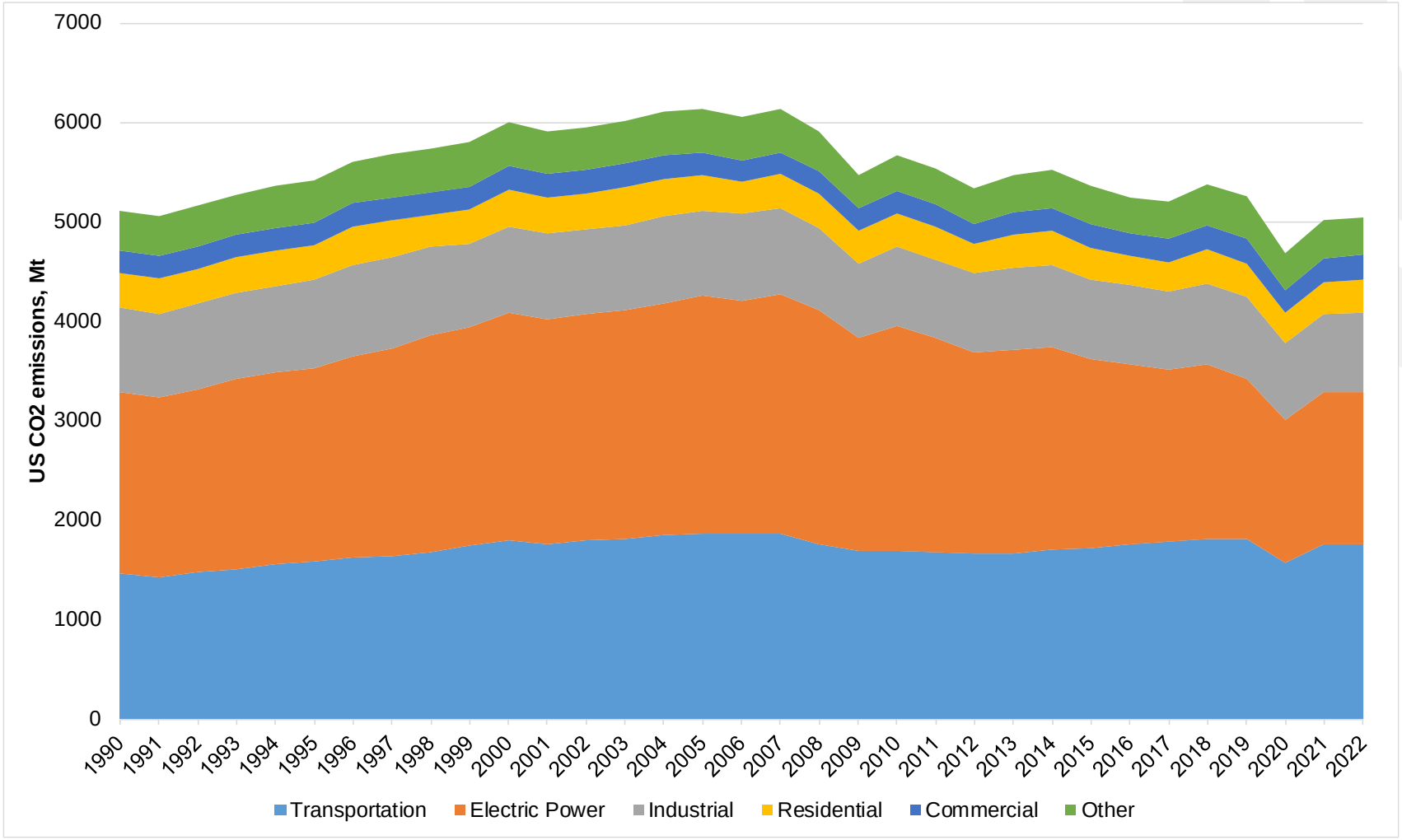

Chart shows US CO2 emissions by sector. Decrease of US emissions in recent years largely driven by the reduction in CO2 emissions from fossil fuel combustion.

It reflects a continued shift from coal to less carbon intensive natural gas and renewables in the electric power sector.

Source:

EPA. 2022. Inventory of Green House Gas Emissions and Sinks. https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2022

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US HISTORICAL CH_4 EMISSIONS

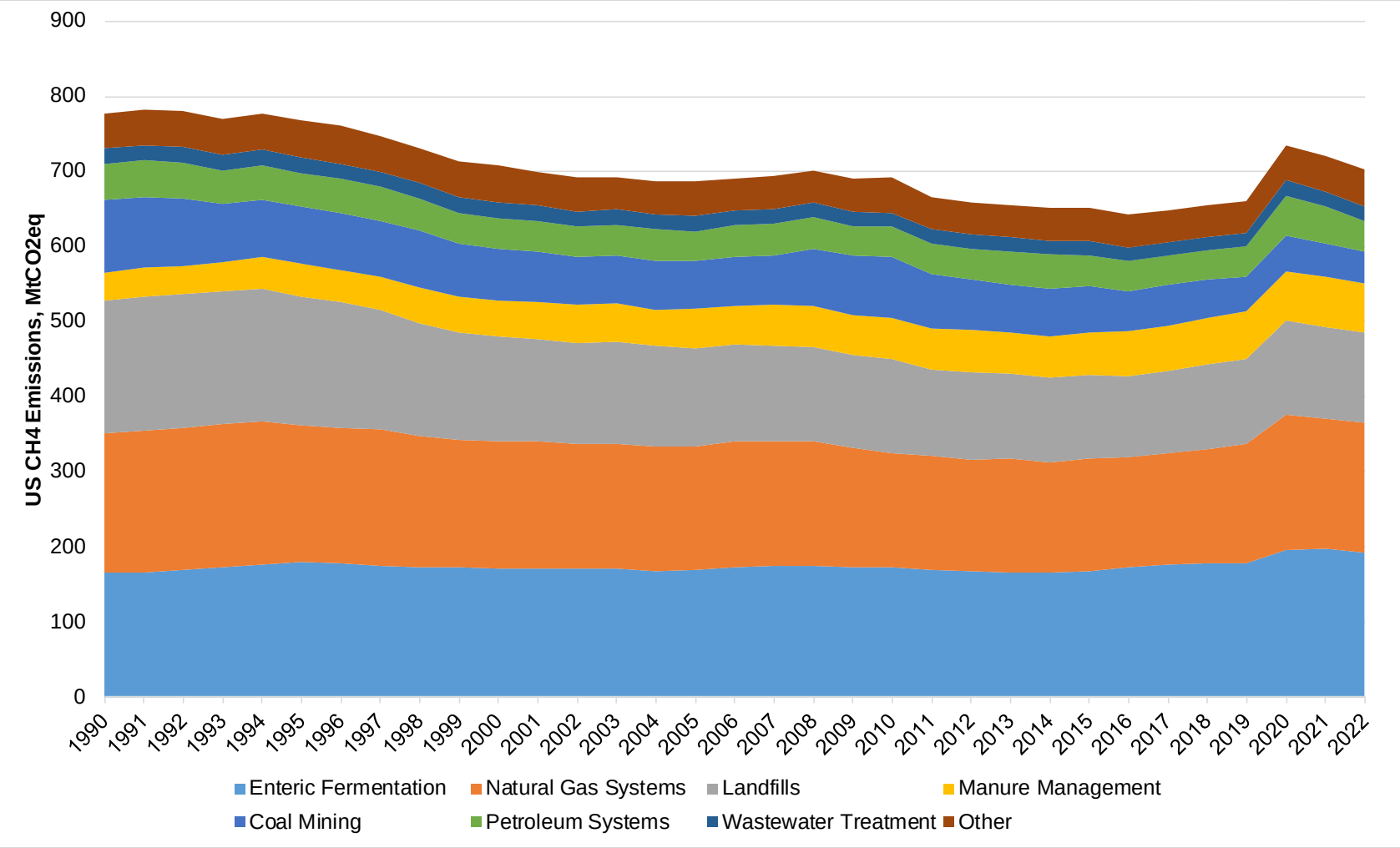

Chart shows US methane emissions by sector. From 1990 to 2022, CH4 emissions from landfills decreased by 56.8 due to landfill gas collection and control systems, and a reduction of decomposable materials

Enteric fermentation from domestic livestock remained relatively flat.

Source:

EPA. 2022. Inventory of Green House Gas Emissions and Sinks. https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2022 and Incorrys Data

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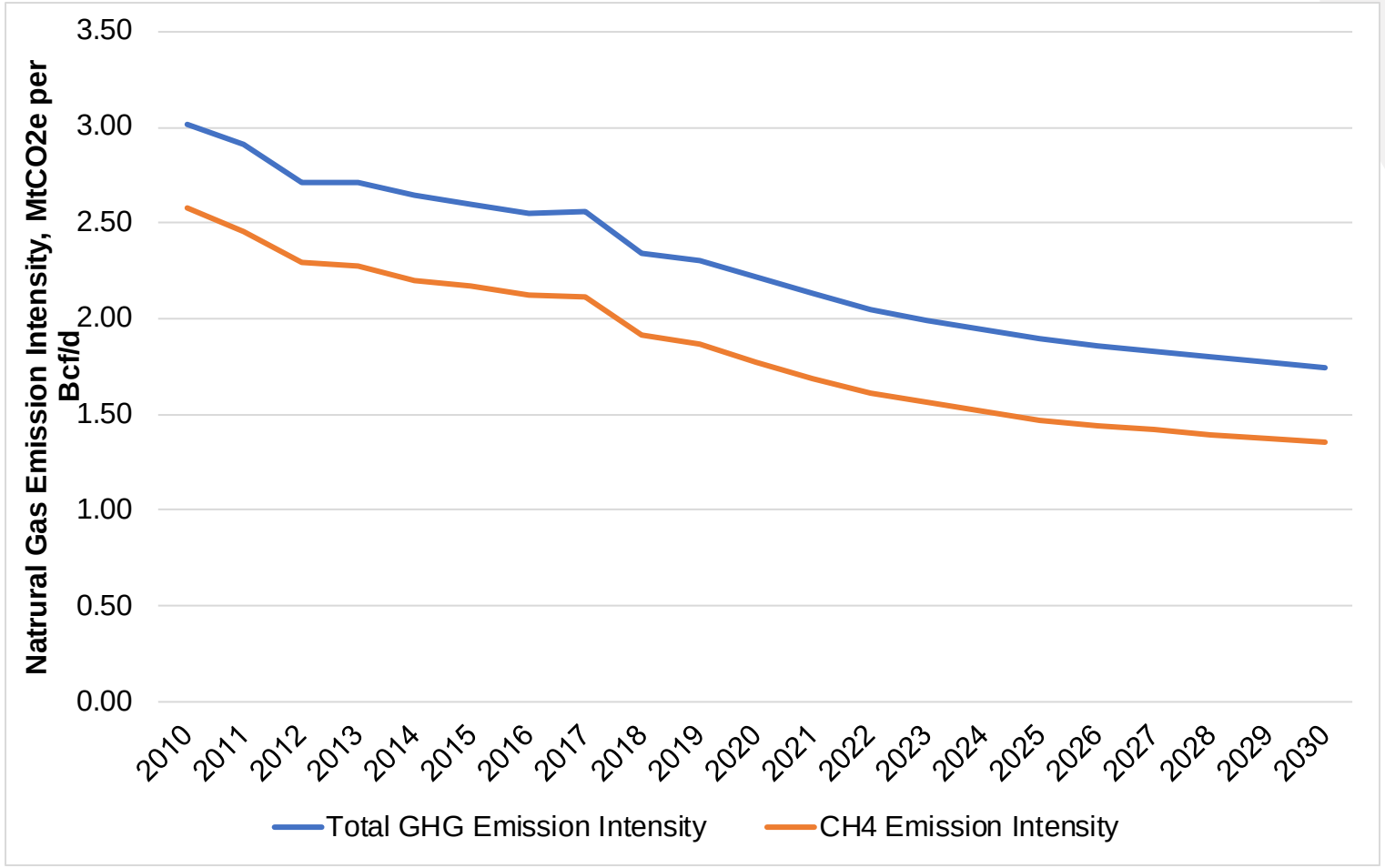
GHG EMISSION INTENSITY FOR NATURAL GAS SYSTEMS



The chart shows natural gas emission intensity calculated as total emissions from Natural gas systems divided on historical and future dry gas productions.

Incorrys also estimated that in 2019 major natural gas producers with liquids production less than 10% had emission intensity ranged from 2 to 6.5 MtCO2eq per Bcf/d.

Emission intensity is expected to decline due to various measures primarily focused on CH4 emission reduction.

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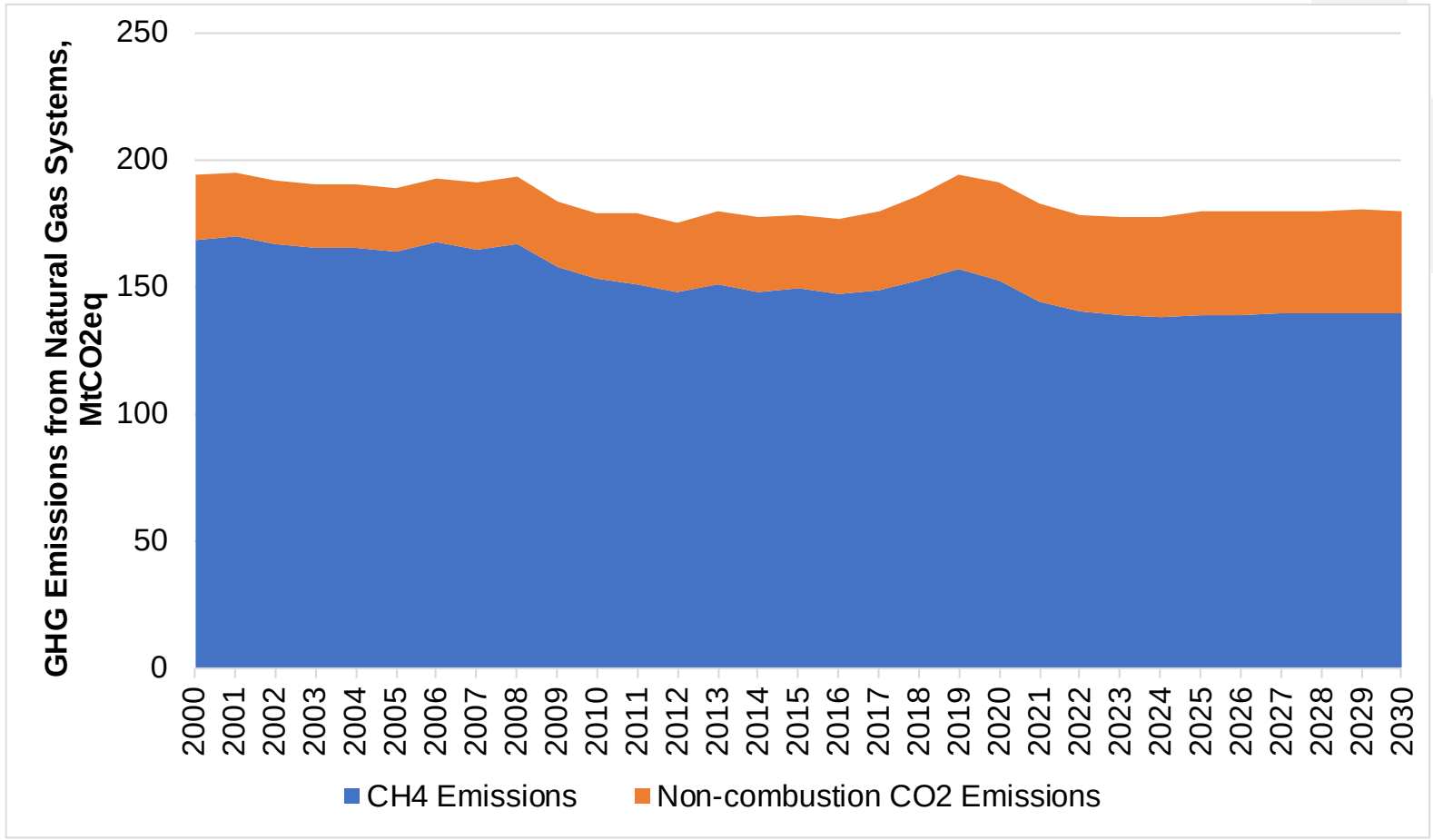
US GHG EMISSIONS FROM NATURAL GAS SYSTEMS



Despite a drop in emission intensity, GHG emissions from Natural Gas System are expected to remain flat or slightly grow due to growth of natural gas production.

Methane is a main source of GHG emissions in natural gas systems. Natural gas systems were the second largest anthropogenic source category of CH4 emissions in the United States in 2019 with 157.6 MtCO2Eq of methane emitted. Those emissions have decreased by 15% since 1990 due to decreases in emissions from distribution, transmission, and storage.

The decrease in distribution emissions is due to emission reductions from pipelines and distribution station leaks. Methane decreases in transmission and storage emissions is largely due to reduced compressor station emissions (including emissions from compressors and equipment leaks).

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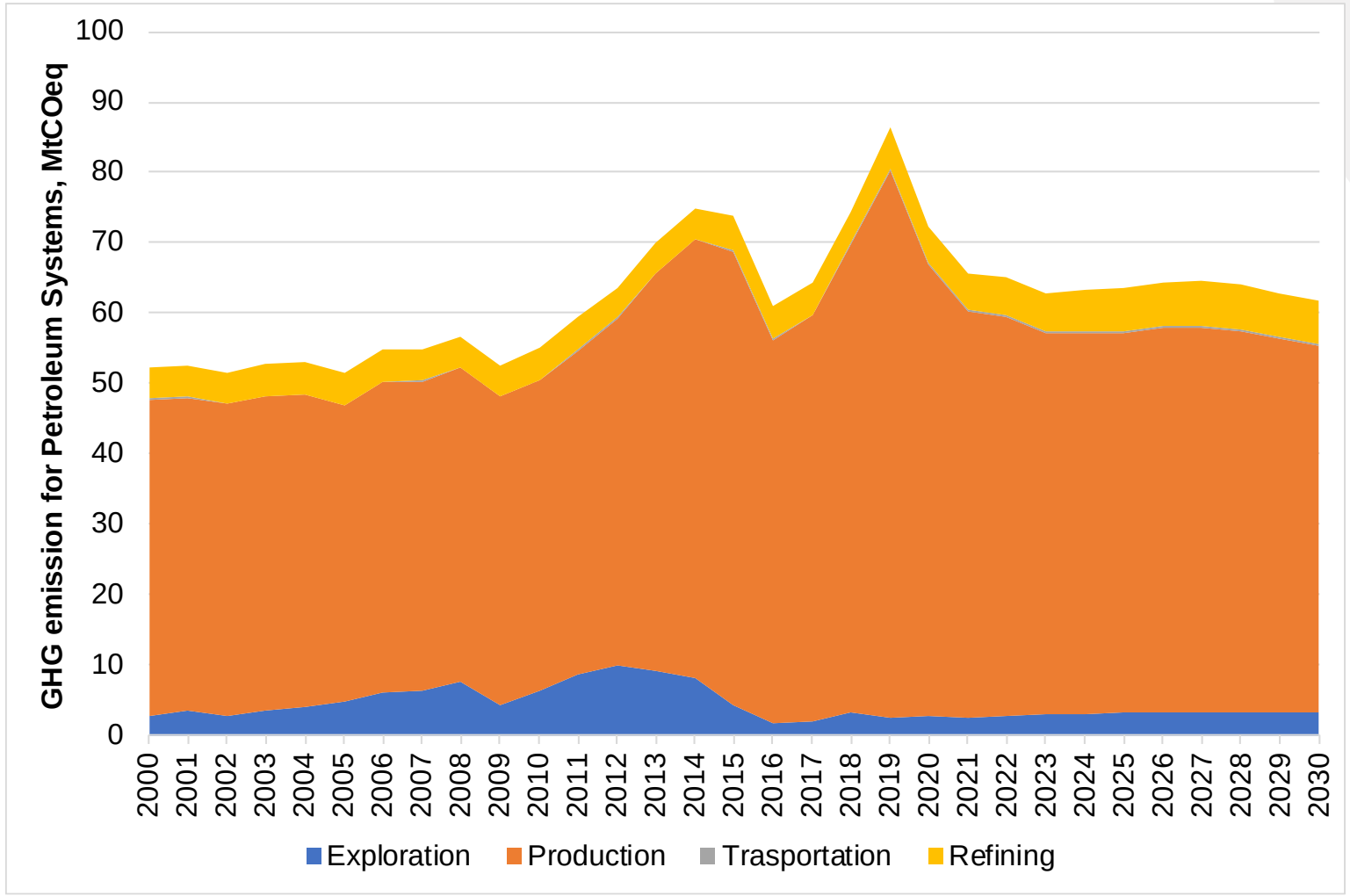
FORECAST OF EMISSIONS FROM US OIL PRODUCTION



The chart shows forecast of GHG emissions from exploration, production, transportation, and refining of oil. It includes mostly fugitive leaks and flaring.

In 2019 GHG emissions reached its peak of 86.4 MtCO2eq primarily because of flaring of associated gas related to Tight Oil production. In 2020-2021 in infrastructure in Permian and mostly in Williston basins led to reduction of flaring and overall reduction of GHG emission.

GHG emission will drop slowly after 2022-23 due to Tight oil production growth and then decline after 2029.

Does include fossil fuel combustion required to produce oil.

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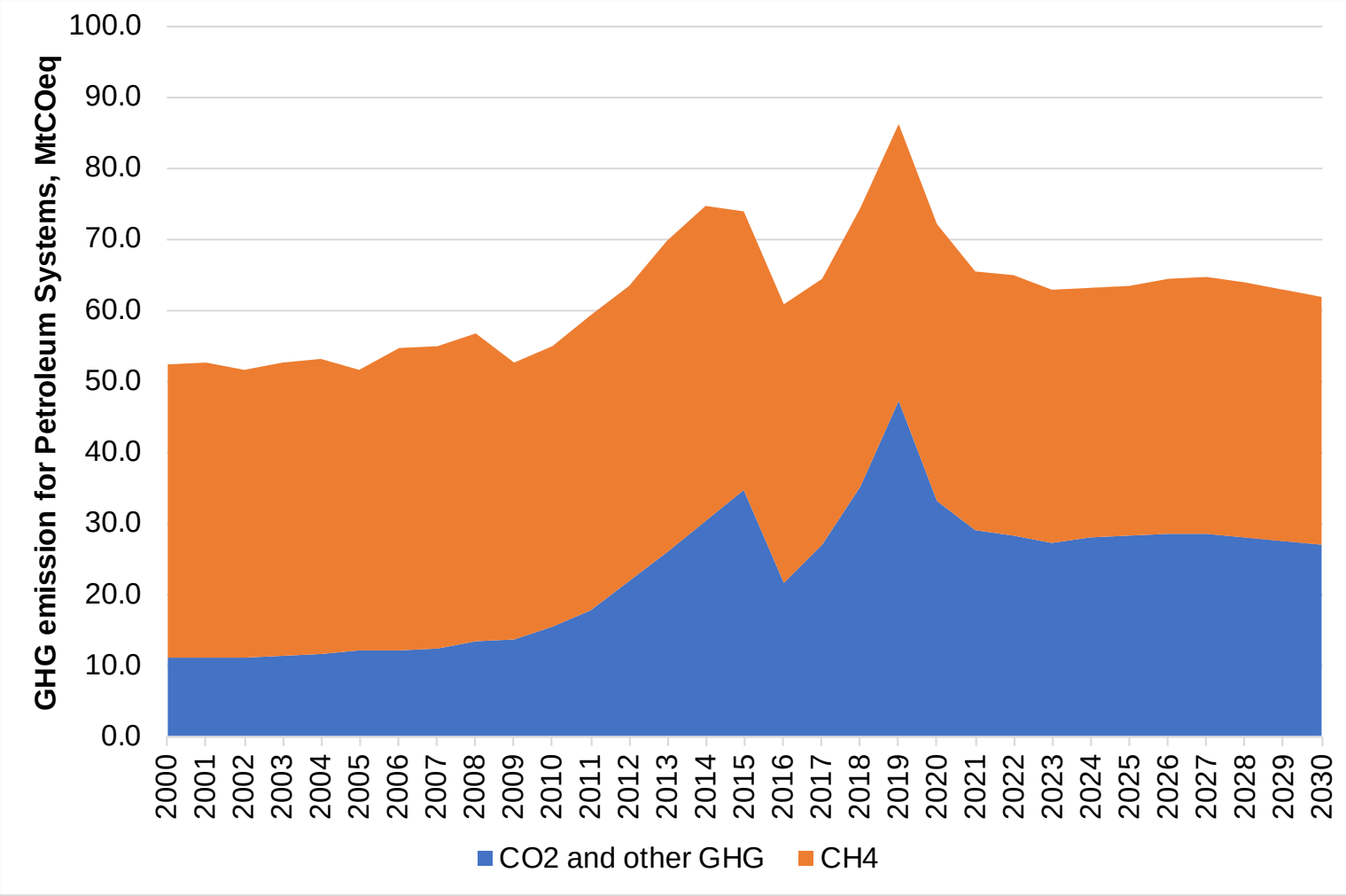
FORECAST OF EMISSIONS FROM US OIL PRODUCTION PER GAS



The chart shows forecast of GHG emissions from oil exploration, production, transportation and refining of oil per green house gas. CO2 and CH4 are mostly emitted by petroleum systems. Emissions of other gases is negligible.

In recent years industry focused on reduction of methane emissions from different fugitive leaks, venting from pneumatic devices, facilities, compressors, and well completions.

CO2 and CH4 emissions come also from flaring, produced water, drilling mug degassing, chemical injection pump and other equipment normal operation and malfunction.

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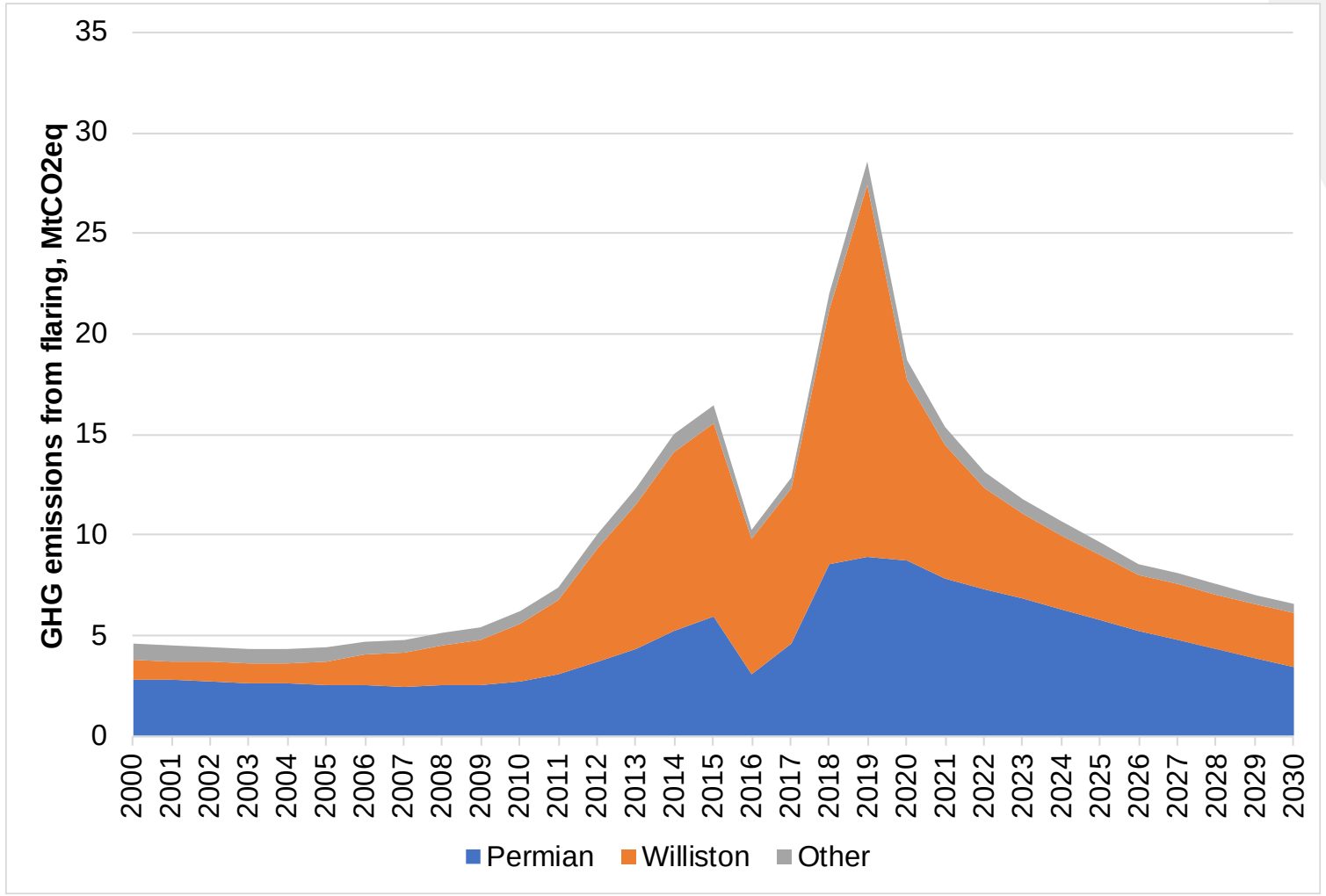
FORECAST OF US EMISSIONS FROM NATURAL GAS FLARING



The chart shows CO2 and CH4 emissions from associated gas flaring. In 2019 flaring emissions reached its peak of 28.6 MtCO2eq primarily due Williston emissions. During this period of time less than 80% was captured. Williston producer invested over USD$20 B in natural gas processing and pipeline infrastructure resulting in 94% capture rate in February 2021. Capture rate is expected to grow in next few years. Even with growth of oil production in Permian and Williston basin GHG emissions from flaring is expected to drop to 6.6 MtCO2eq in 2030 down from 28.6 MtCO2eq in 2019.

Incorrys performed forecast for flaring based on analysis on processing and pipeline infrastructure, associated gas supply forecast and government regulations.

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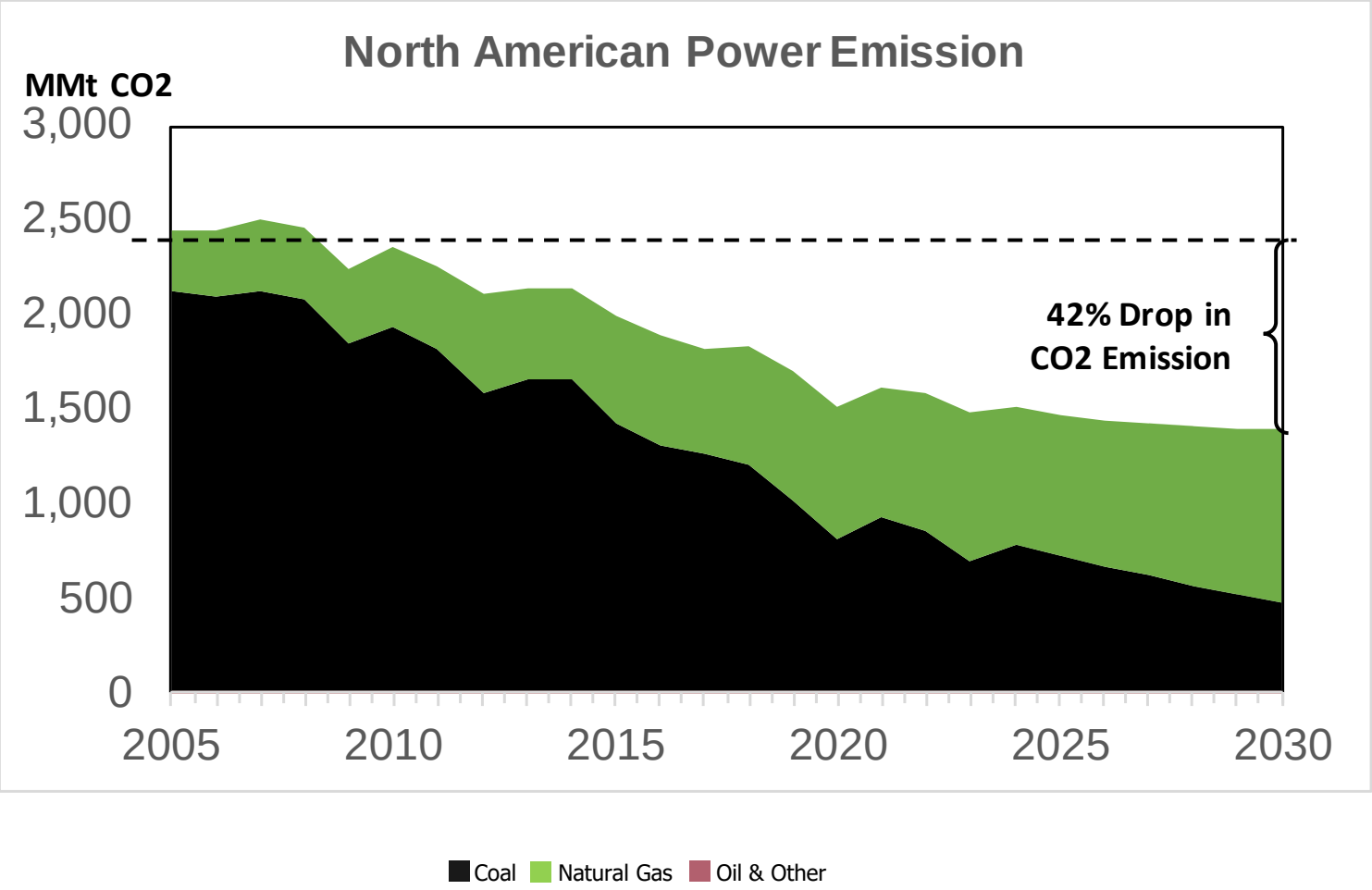
NORTH AMERICAN POWER EMISSIONS TO 2030



- Based on 2019 EIA data, coal fired electricity emits 1 Million Tonnes (MMt) of CO2 per TWh versus natural gas at 0.4 MMt of CO2 per TWh
- In 2005, Coal-fired generation of 330 GW of capacity operated at 73% load factor; by 2030, 125 GW of capacity will operate at just 50% load factor.
- From 2005-2030, coal fired generation will drop 1,575 TWh resulting in a 75% reduction in coal fired carbon emissions.
- From 2005-2030, natural gas fired generation will increase 1,355 TWh, replacing much of the lost coal fired declines. Natural gas emissions will grow 70%, however, overall emissions will drop 42%.

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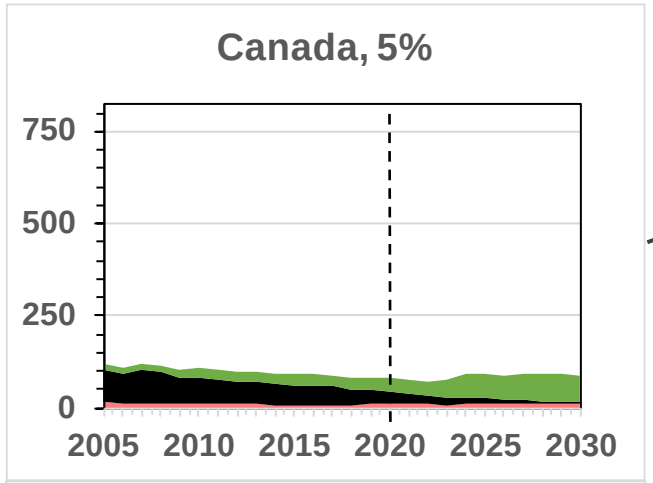
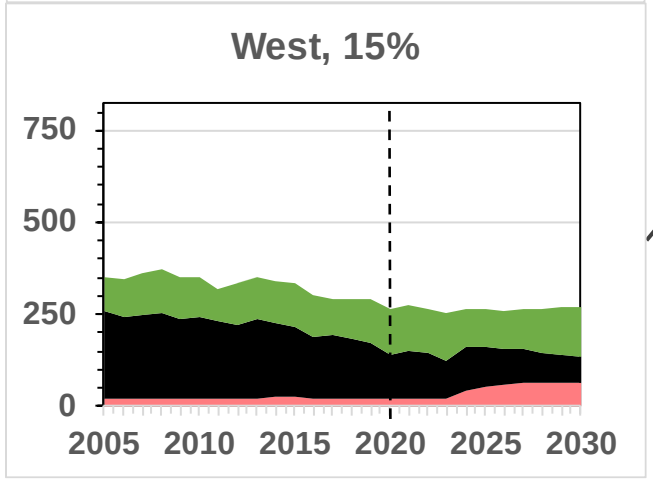
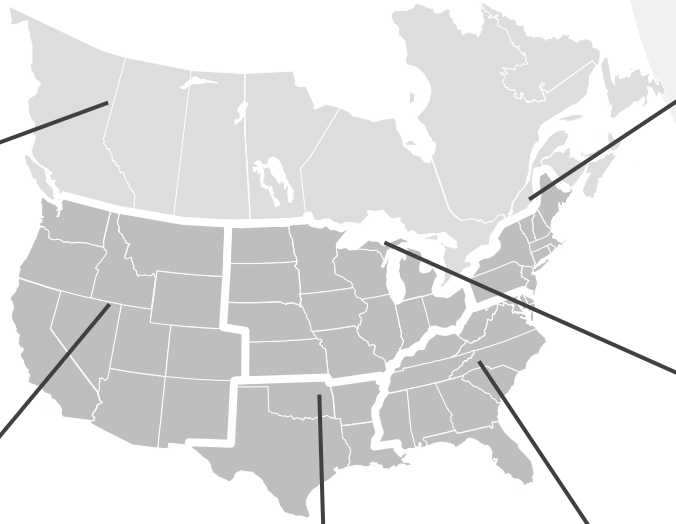
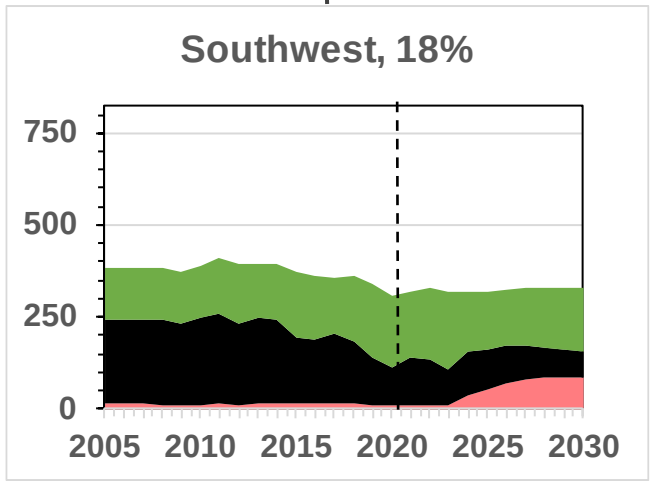
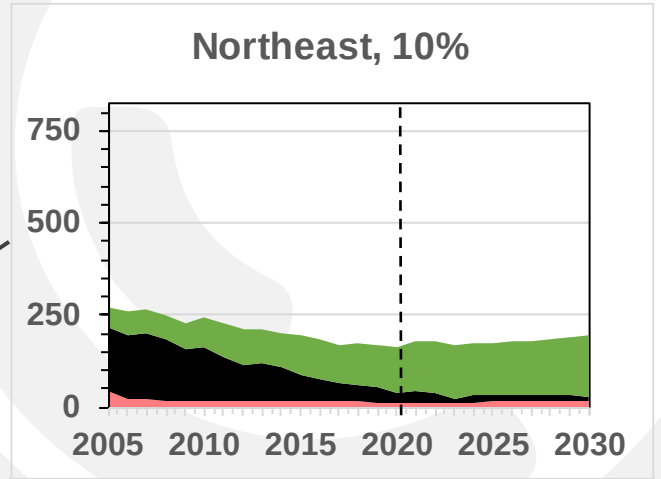
NORTH AMERICAN POWER EMISSIONS OUTLOOK BY REGION, MTCO2EQ

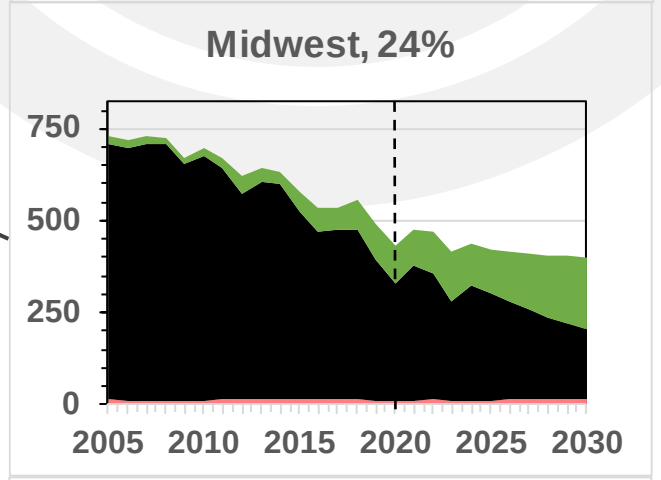


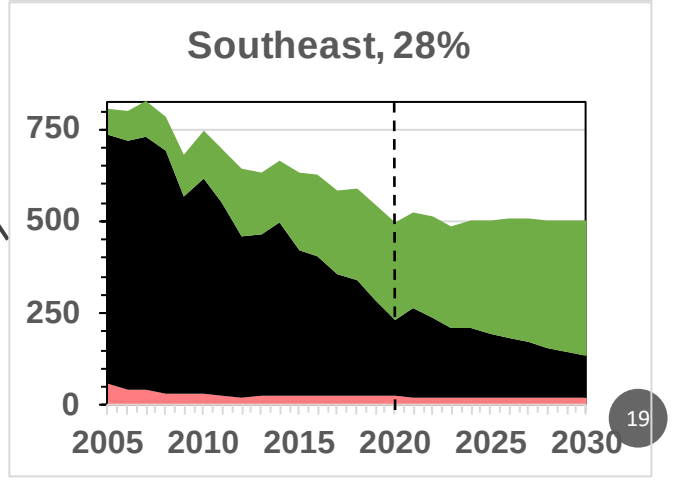












Coal
Natural Gas
Oil & Other
Region, % NA Market Share

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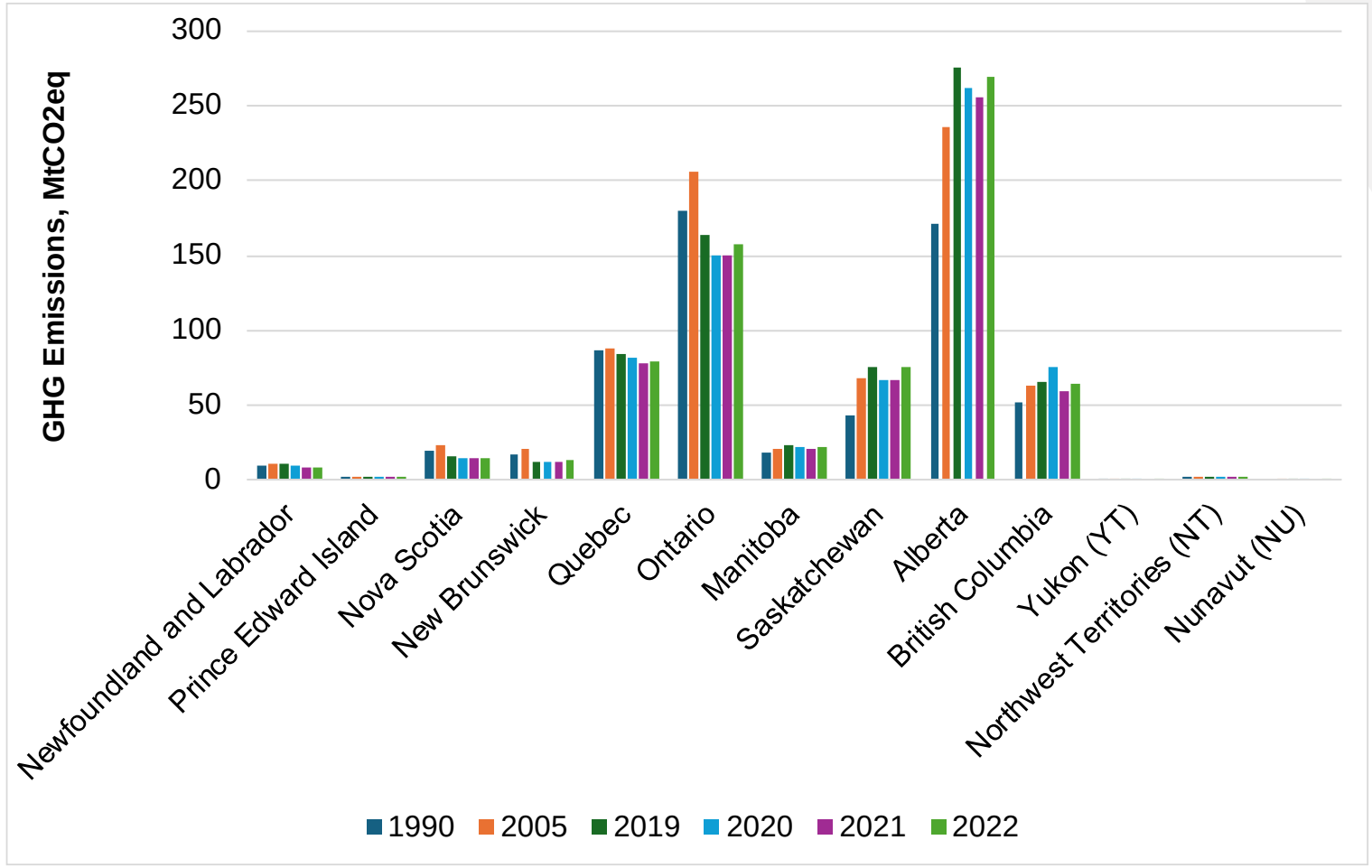
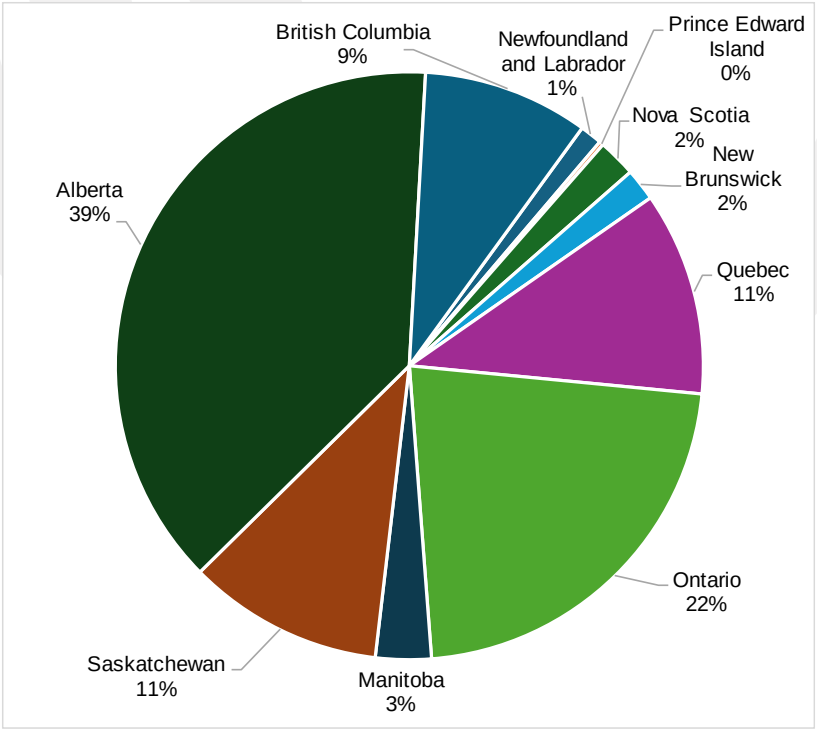
CANADIAN GHG EMISSIONS PER PROVINCE



Source: Government of Canada
https://www.canada.ca/en/environment-climate-change/services/environmental-indicators/greenhouse-gas-emissions.html



Alberta has the largest emissions in Canada primarily due to oil and gas sector. Ontario's emissions decreased between 1990 and 2022 mostly because of the closure of coal-fired electricity generation plants.

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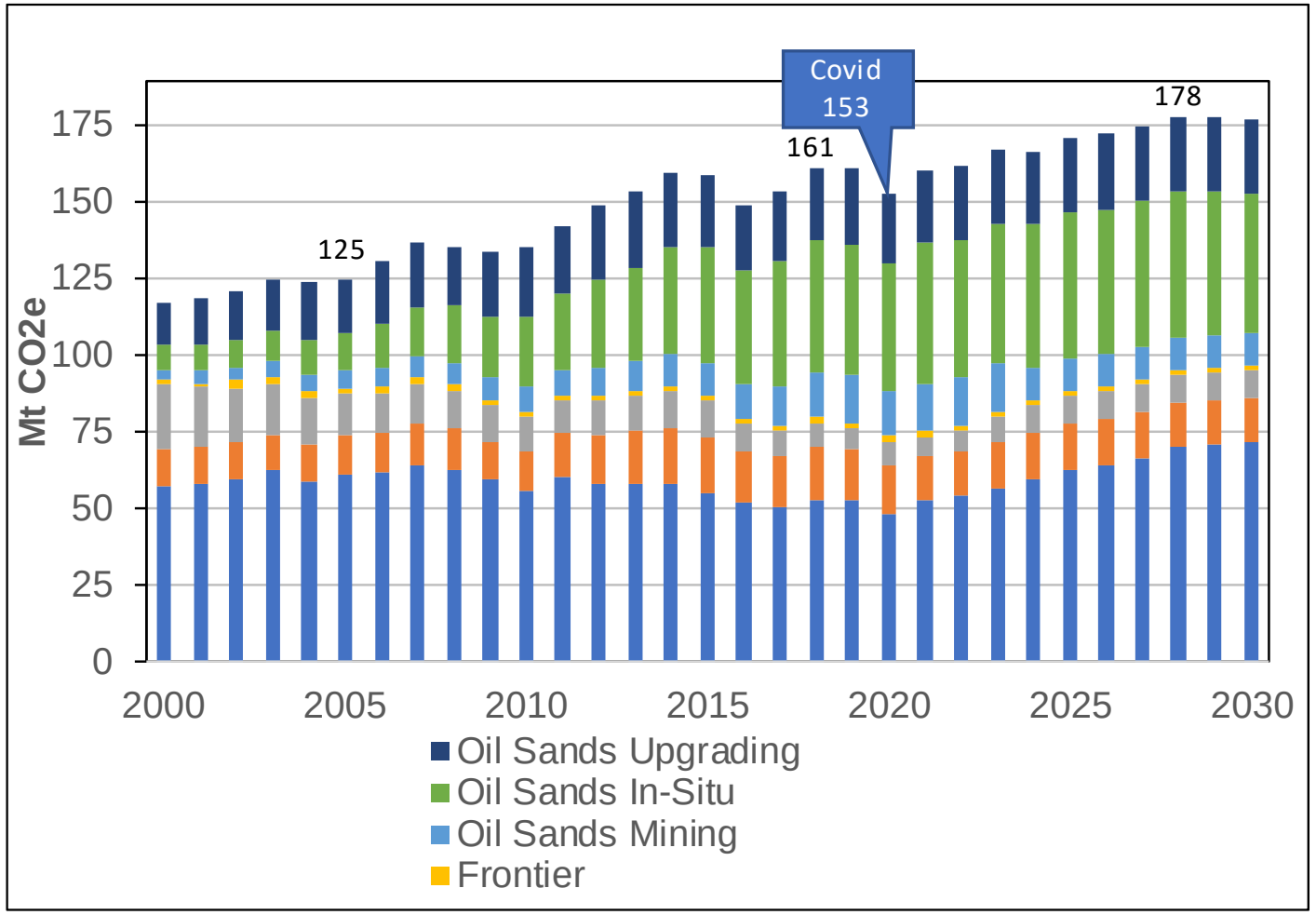
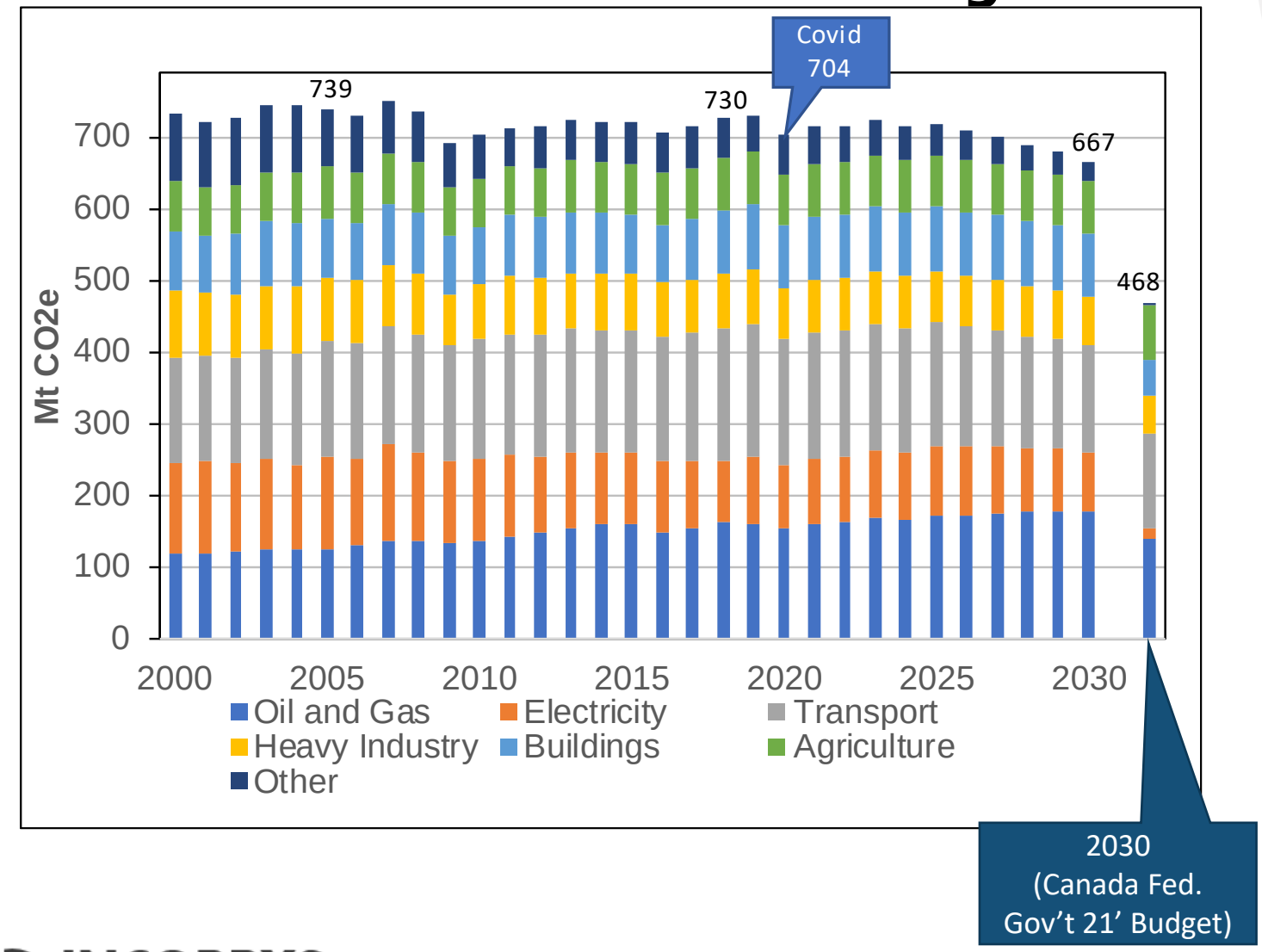
CANADIAN OIL AND GAS EMISSIONS



- Natural gas sector increases are driven by increasing production required for the LNG Canada export terminal expected to begin in 2024.
- Light and Heavy Conventional oil are expected to decline slightly while Frontier (Newfoundland offshore) is expected to be flat.
- Oil sands Mining sector emissions intensity is expected to benefit with Suncor's switching from coke boiler to cogeneration in late 2023. Overall mining emission intensity drops 33% during the forecast period.
- Oil sands in-situ intensity is expected to be reduced 18% due to switching to solvent/steam mixtures for subsurface efficiencies and carbon capture and storage solutions.

CANADIAN EMISSIONS TO 2030



- Growth in natural gas production (LNG exports to replace International coal-fired power) is expected to drive oil and gas sector increases of 25 MtCO2e.
- Closing of coal-fired capacity and replacing with natural gas units reduce electricity sector emissions 6.2%.
- Transportation sector declines 28.5 MtCO2e driven by increased EV market share to 15% of total vehicle registration and strengthening Canadian fuel standards biofuel content.
- Building emissions remain static as overall housing stock increases 14%.
- Agriculture sector remains flat.
- Other sector declines 26.5 MtCO2e as forest projects and cropland conversions drive emissions lower.
- Assuming GDP grows at 2.2%/year, Incorrys does not foresee Canada meeting current 2030 target outlined in the 2021 Budget.

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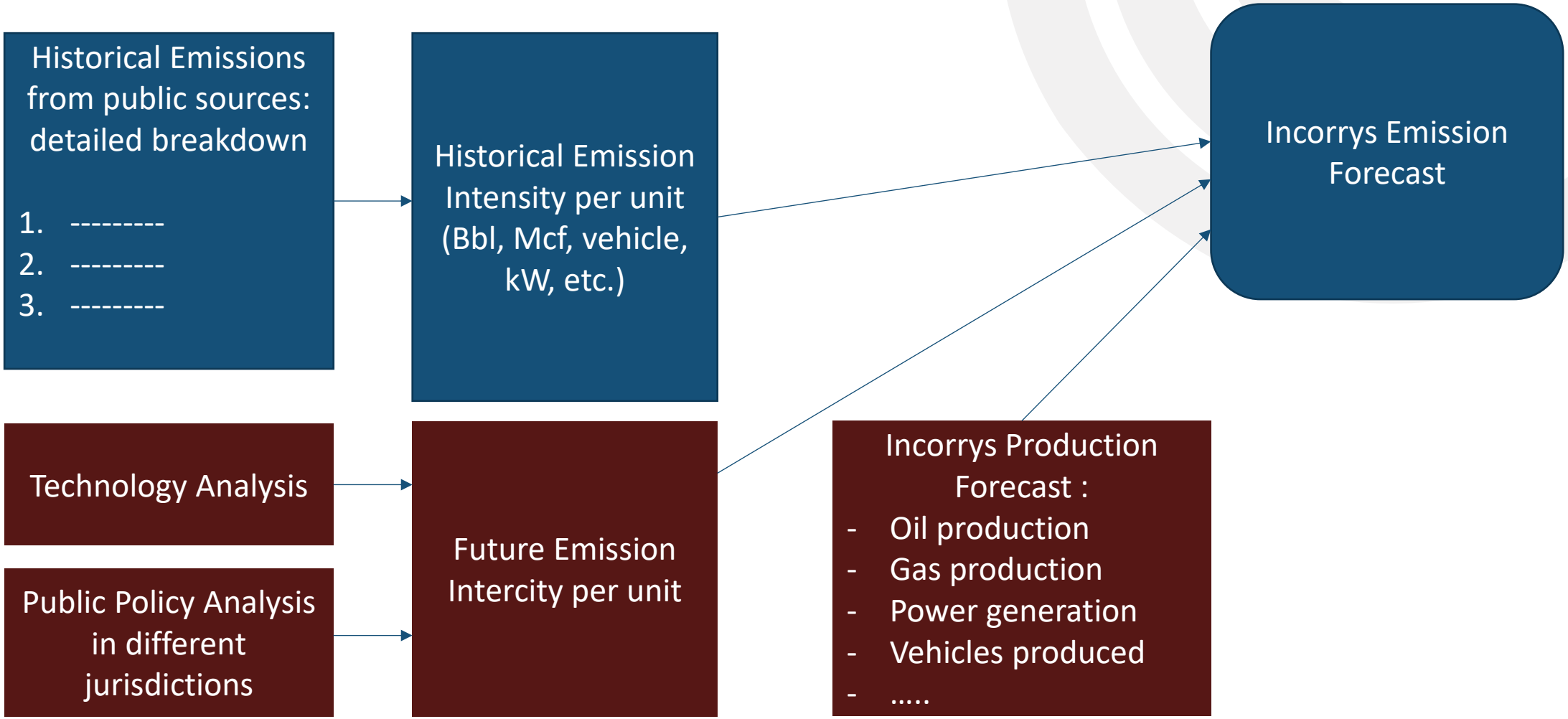
INCORRYS METHODOLOGY TO FORECAST EMISSIONS



THANK YOU !

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