A comparative analysis of North America and Latin America & Caribbean's contribution to renewable energy; and their adoption to climate mitigation efforts from 1960 to 2023

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1 Introduction

The global transition toward renewable energy and the adoption of climate mitigation strategies are critical for combating climate change. This report presents a comparative analysis of the contributions and progress of North America and Latin America & Caribbean in renewable energy adoption and climate mitigation efforts over the period 1960 to 2023. It also evaluates and compares trends in renewable energy production, fossil fuel dependency, and emissions of greenhouse gases, including CO2, methane, and nitrous oxide, across the two regions. Using data from the World Bank, it examines how these regions have addressed the dual challenges of energy security and climate change while considering their unique geographical, economic, and policy contexts.

2 Used Data

Region	**Data Source: World Bank API**
North America	Download
Latin America & Caribbean	Download
Metadata URL	Link
Data Type	csv
Data License	Creative Commons Attribution 4.0 International License (CC BY 4.0)

Table 1: Data Sources and License for Various Regions

The dataset was obtained from the World Bank's API, covering regions such as **North America** and **Latin America & Caribbean**. The data was provided in zipped files containing three CSV files, of which two were utilized: one for the main dataset and the other for metadata about the indicators. During **data preparation**, unnecessary columns (e.g., "Unnamed" columns) and missing values (`NaN`) were removed. Missing values were either replaced with 0 or interpolated to maintain continuity in the time series. For **data integration**, the metadata columns were renamed to ensure consistency, particularly renaming a key column to "Indicator Code" to facilitate merging with the main dataset. Finally, the cleaned and merged data was stored in SQLite, with columns renamed for consistency:

- "Country Name" → "CountryName"
- "Country Code" → "CountryCode"
- "Indicator Name" → "IndicatorName"
- "Indicator Code" → "IndicatorCode"
- "SOURCE_NOTE" → "SourceNote"
- "SOURCE_ORGANIZATION" → "SourceOrganization"

Below is table of Indicator Code and their names that frequently appear in the diagrams and representations.

Indicator Code	Indicator Name
EN.GHG.TOT.ZG.AR5	Total greenhouse gas emissions excluding LULUCF (% change from 1990)
EN.GHG.CO2.RT.GDP.PP.KD	Carbon intensity of GDP (kg CO2e per 2021 PPP $ of GDP)
EN.GHG.CO2.MT.CE.AR5	Carbon dioxide (CO2) emissions (total) excluding LULUCF (Mt CO2e)
EN.GHG.CO2.ZG.AR5	Carbon dioxide (CO2) emissions (total) excluding LULUCF (% change from 1990)
EN.GHG.CO2.RT.GDP.KD	Carbon intensity of GDP (kg CO2e per constant 2015 US$ of GDP)
EN.GHG.CH4.WA.MT.CE.AR5	Methane (CH4) emissions from Waste (Mt CO2e)
EN.GHG.CH4.TR.MT.CE.AR5	Methane (CH4) emissions from Transport (Energy) (Mt CO2e)
EN.GHG.CH4.IC.MT.CE.AR5	Methane (CH4) emissions from Industrial Combustion (Energy) (Mt CO2e)
EN.GHG.N2O.TR.MT.CE.AR5	Nitrous oxide (N2O) emissions from Transport (Energy) (Mt CO2e)
EN.GHG.N2O.IC.MT.CE.AR5	Nitrous oxide (N2O) emissions from Industrial Combustion (Energy) (Mt CO2e)
EN.GHG.N2O.PI.MT.CE.AR5	Nitrous oxide (N2O) emissions from Power Industry (Energy) (Mt CO2e)
EN.GHG.N2O.FE.MT.CE.AR5	Nitrous oxide (N2O) emissions from Fugitive Emissions (Energy) (Mt CO2e)
EG.ELC.RNWX.ZS	Electricity production from renewable sources, excluding hydroelectric (% of total)
EG.FEC.RNEW.ZS	Renewable energy consumption (% of total final energy consumption)
EG.ELC.HYRO.ZS	Electricity production from hydroelectric sources (% of total)
EG.ELC.RNWX.KH	Electricity production from renewable sources, excluding hydroelectric (kWh)
EG.ELC.FOSL.ZS	Electricity production from oil, gas and coal sources (% of total)
EG.ELC.PETR.ZS	Electricity production from oil sources (% of total)
EG.ELC.NGAS.ZS	Electricity production from natural gas sources (% of total)
EG.ELC.COAL.ZS	Electricity production from coal sources (% of total)
EG.ELC.NUCL.ZS	Electricity production from nuclear sources (% of total)

LULUCF: Land Use, Land-Use Change, and Forestry

3 Analysis

The primary objective of this analysis was to visually inspect and compare regional economic trends in North America (NAC) and Latin America (LCN) across three key areas: renewable energy adoption, climate mitigation efforts, and environmental impact from 1960 to 2023. The analysis aimed to provide insights into how these regions are performing in terms of sustainability and environmental policies.

3.1 Data Selection

Key indicators related to renewable energy, fossil fuel dependency, and greenhouse gas (GHG) emissions (CO2, methane, and nitrous oxide) were identified and extracted for both regions. The list of indicators and their names are listed below:

3.2 Data Visualization

- Comparative line plots were created for renewable energy adoption, fossil fuel dependency, and emissions trends using consistent metrics.
- Separate analyses were conducted for total emissions, Nitrous Oxide(N_2O) emissions, Methane(CH_4) emissions, and Carbon dioxide(CO_2) emissions.

4 Results

4.1 Renewable Energy Adoption

It is measured by `EG.ELC.RNWX.ZS` (renewable electricity generation as % of total). The x-axis represents years from 1960 to 2020 and the y-axis represents energy consumption in joules.

- **Renewable Energy Adoption:** Renewable energy adoption has increased significantly in NAC since the 2000s, driven by policy support and declining technology costs, while LCN has a higher reliance on renewables, primarily due to abundant hydroelectric resources, though growth in solar and wind has been slower, highlighting the need for diversification.
- **Fossil Energy Adoption:** Fossil fuel usage in NAC has declined, particularly coal, as natural gas and renewables gain traction, whereas LCN's fossil fuel reliance has increased due to growing energy demand and limited renewable investment beyond hydroelectric power.
- **Nuclear Energy Adoption:** Nuclear energy remained a stable and significant part of the NAC's energy mix until the mid-1980s, despite stagnant growth due to high costs and public opposition, but the nuclear usage of LCN became minimal, reflecting its dependence on other energy sources and limited investment in nuclear infrastructure.

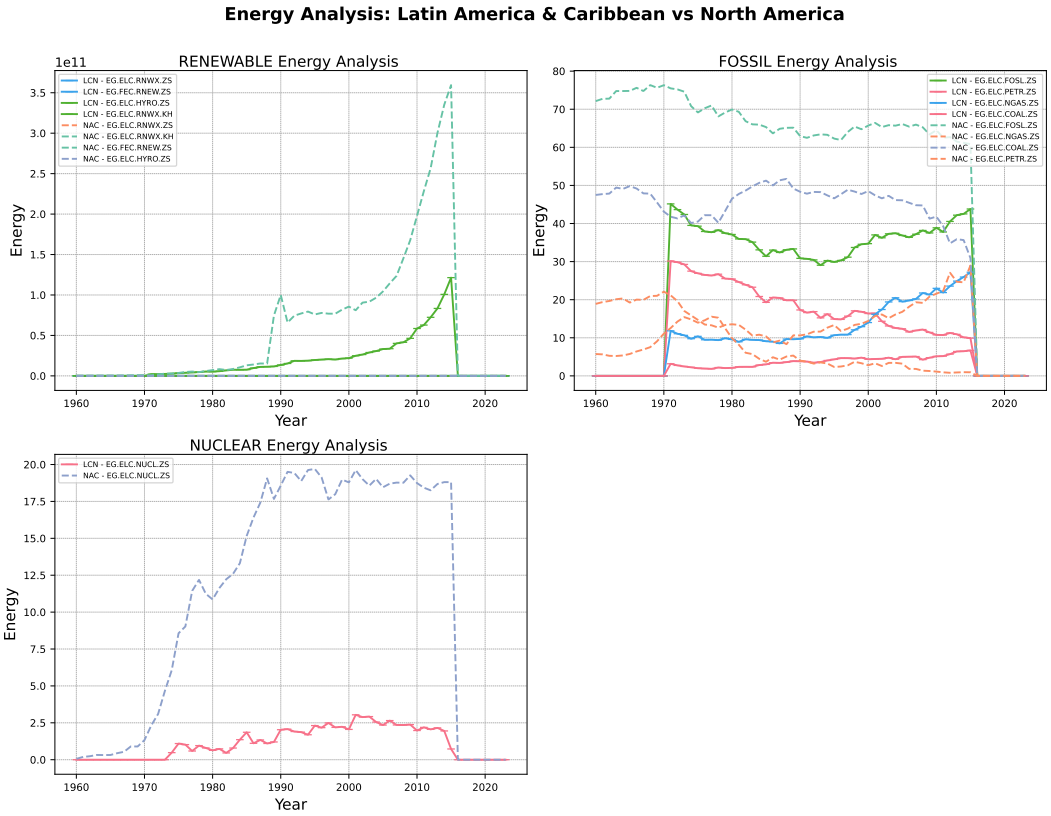

Figure 1: Renewable Energy Consumption vs Year

- **Key Insights:** NAC is transitioning to cleaner energy sources, with declining fossil fuel usage and growing renewable energy adoption whereas, LCN relies heavily on hydroelectric power but needs to diversify its renewable energy mix and reduce fossil fuel dependence.

4.2 Greenhouse Gas Emissions

It is tracked by `EN.GHG.TOT.ZG.AR5` (total greenhouse gas emissions excluding LULUCF). The x-axis represents years from 1960 to 2020 and the y-axis represents emissions in Metric Tons (MT).

- **Total Emissions:** Total GHG emissions (`EN.GHG.TOT.ZG.AR5`) in NAC are significantly higher than LCN, reflecting the region's industrial base and population size. However, emissions have shown a gradual decline since the 2000s, likely due to stricter environmental regulations and a shift toward cleaner energy sources.

- **CO_2 Emissions:** NAC's CO_2 emissions peaked in the early 2000s and have since declined, driven by the adoption of renewable energy, energy efficiency measures, and a shift from coal to natural gas. LCN shows a lower trajectory of CO_2 emissions, consistent with its renewable energy usage.
- **CH_4 Emissions:** In NAC, methane emissions have declined in recent decades, particularly from industrial combustion, likely on account of certain regulationss and technological advancements. But in LCN, they seem to have increased, especially from waste and industrial combustion, driven by urbanization and industrial growth. However, the rise has been consistent since the 1990s.
- **N_2O Emissions:** Nitrous oxide emissions have declined in North America, particularly since the 1990s reflecting improvements but this has increased in Latin America & Caribbeans likely due to industrial combustion.

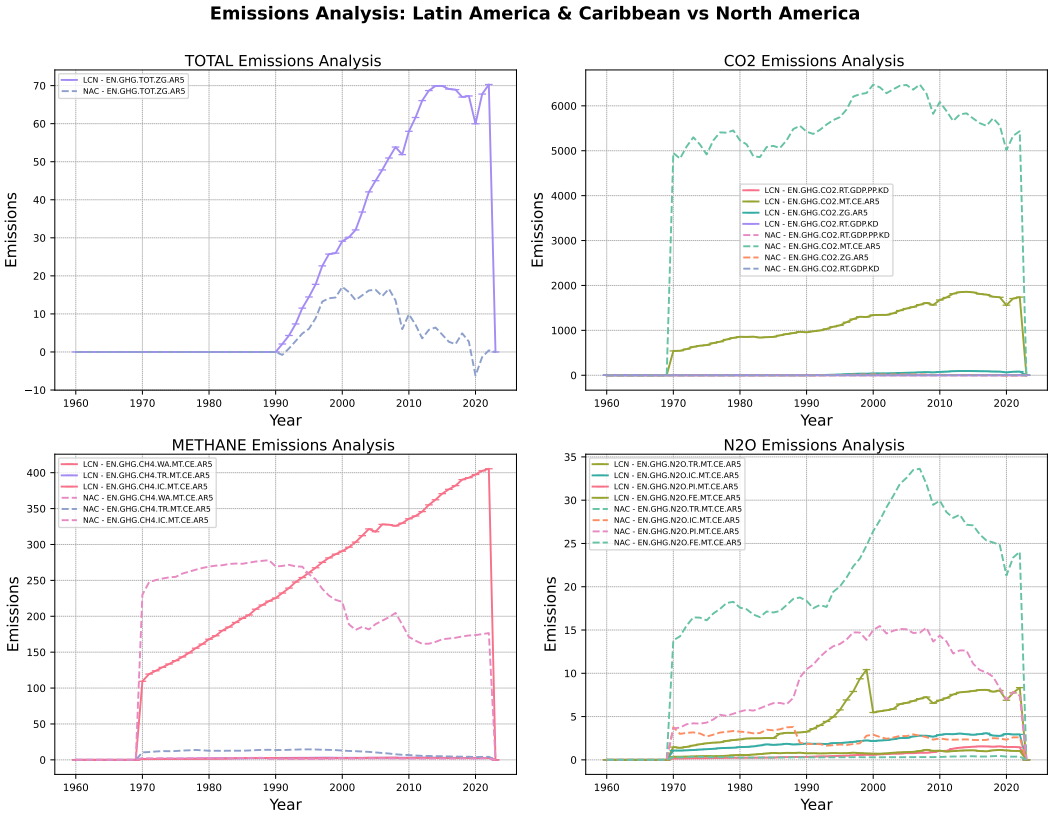

Figure 2: Green House Gas Emission vs Year

- **Key Insights:** NAC has made significant progress in reducing total emissions and CO_2 emissions, while LCN faces challenges in decoupling emissions from economic growth. However, Methane and N_2O emissions are rising in LCN, particularly from industrial and waste sectors, requiring targeted mitigation efforts.

5 Conclusion

This comparative study reveals that **Latin America & Caribbean (LCN)** and **North America (NAC)** have followed distinct paths in renewable energy adoption and climate mitigation. NAC has significantly reduced emissions since the 2000s by transitioning to renewables and improving energy efficiency, while LCN relies heavily on hydroelectric power but lags in diversifying its renewable energy mix. Both regions should prioritize decarbonization, with NAC accelerating renewable adoption and LCN diversifying beyond hydroelectric power. In this way, they can enhance their contributions to global climate goals and sustainable development.