Introduction & Dataset Overview

Introduction:

This report analyzes global CO_2 emission trends and electricity carbon intensity to understand how regional energy grids influence the carbon footprint of AI and cloud workloads. As digital infrastructure expands rapidly, measuring and reducing emissions has become essential for sustainable technology operations. Using publicly available datasets from Our World in Data (OWID), this analysis examines historical trends, regional differences, and country-level emission patterns to identify practical opportunities for reducing carbon impact through better workload placement and optimized AI practices.

Dataset Overview:

CO_2 Emissions Dataset
- Shape: ~60,000 rows
- Key fields: country, iso_code, year, co2
- Preprocessing: Removed aggregate regions (OWID codes), filtered real countries, handled missing values

Carbon Intensity Dataset
- Shape: ~5,700 rows
- Key fields: entity, year, carbon_intensity
- Preprocessing: Selected regions (India, United States, World) and removed missing values

Global CO₂ Emissions (World) – 1990 onwards
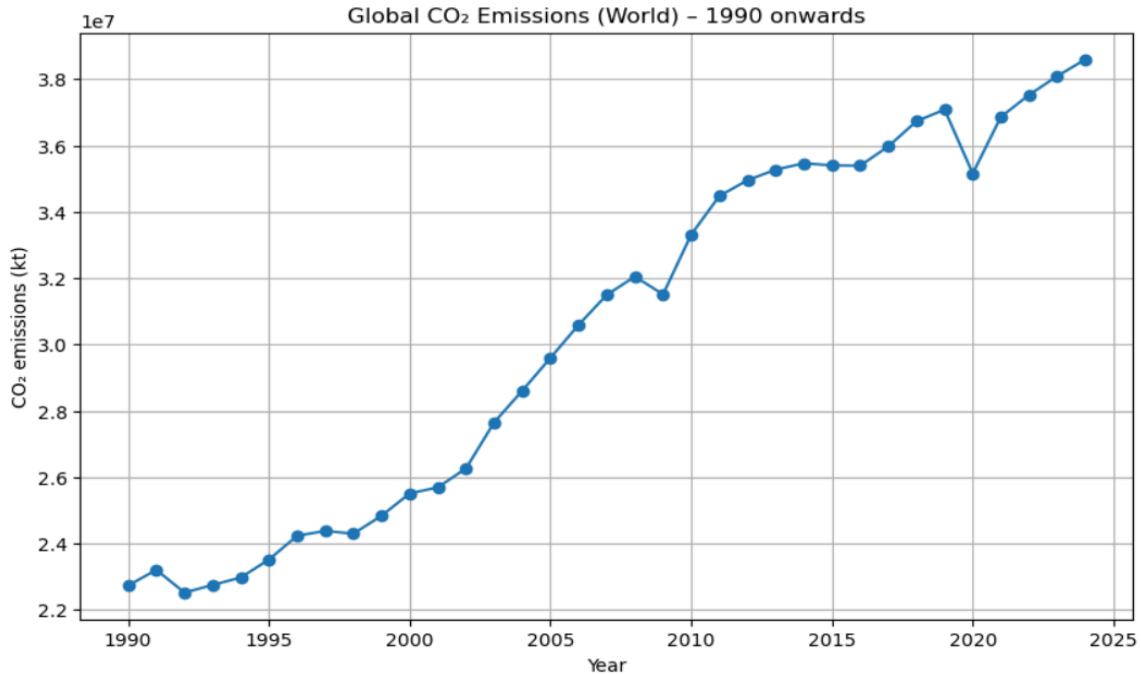
Insights:
• Emissions have steadily increased since 1990.
• Only small temporary dips occur but overall growth persists.
• Fossil fuel dependence continues to dominate global energy use.

Global CO₂ Emissions – Historical Trend and 5-Year Projection
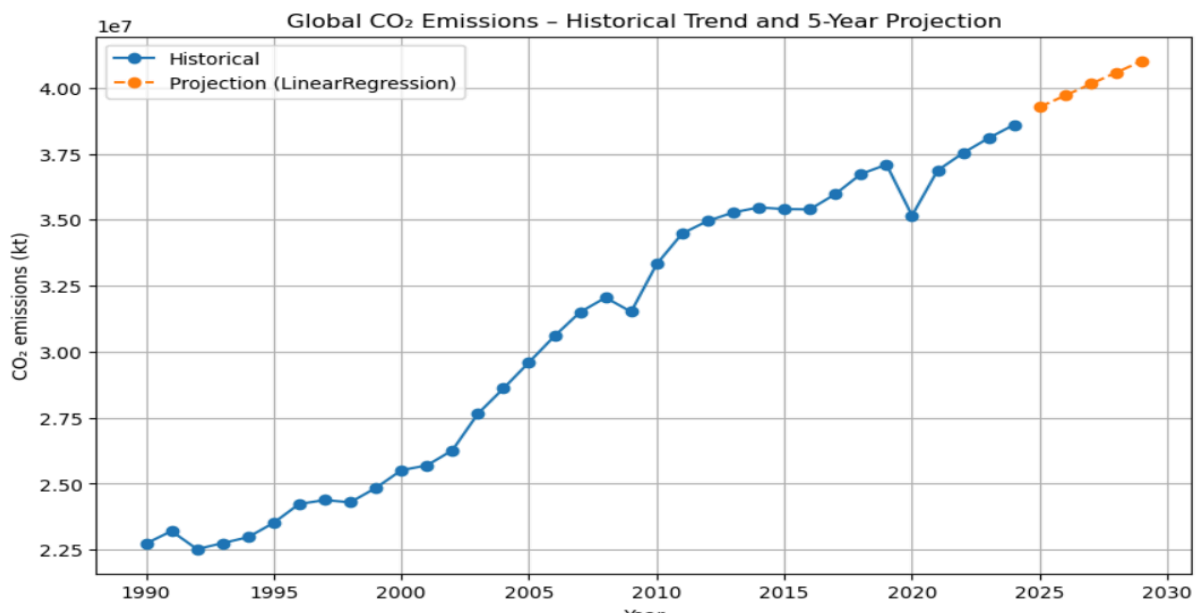
Insights:
• LinearRegression shows emissions rising further in the next 5 years.
• No evidence of stabilization in the near term.
• The global decarbonization rate is insufficient to reverse the trend.

Latest year in intensity data: 2024
   entity   Code   year   intensity_gco2_per_kwh
48   India   IND   2024   708.3216
73   United States   USA   2024   383.5492
98   World   OWID_WRL   2024   473.0065

Electricity Carbon Intensity by Region – 2024
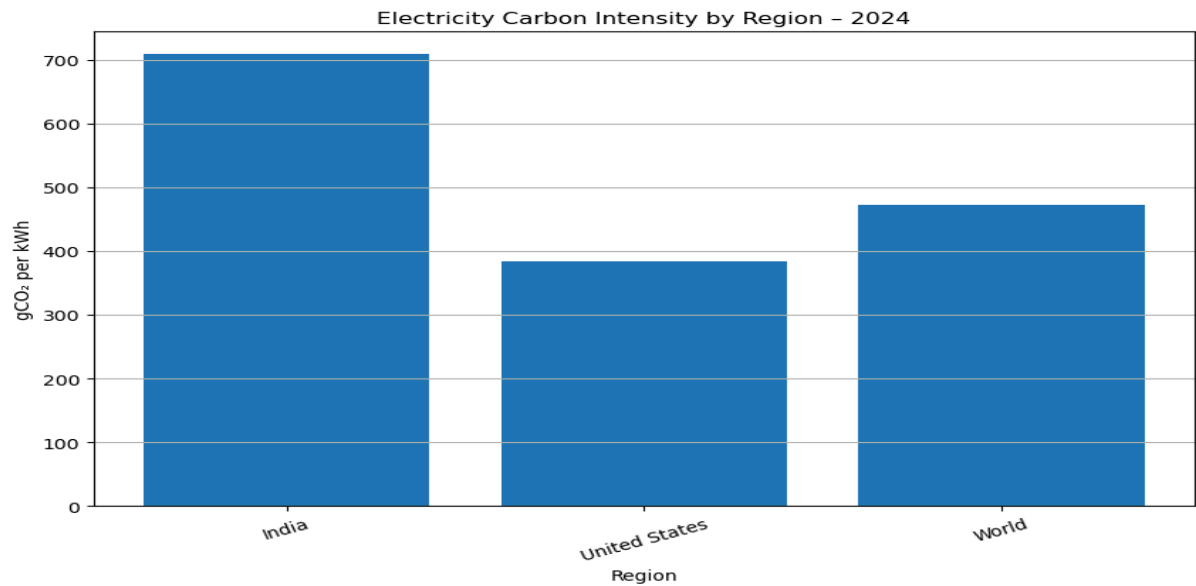
Insights:

- India has the highest carbon intensity (~708 gCO$_2$/kWh).
- The US grid is significantly cleaner (~383 gCO$_2$/kWh).
- Region choice directly impacts the emissions produced by cloud workloads.

Top 5 CO₂ emitting countries in 2024:
              country   co2
9933   China   12289.037
48003   United States   4904.120
21762   India   3193.478
38311   Russia   1780.524
23812   Japan   961.867

Top 5 CO$_2$ Emitting Countries – 2024
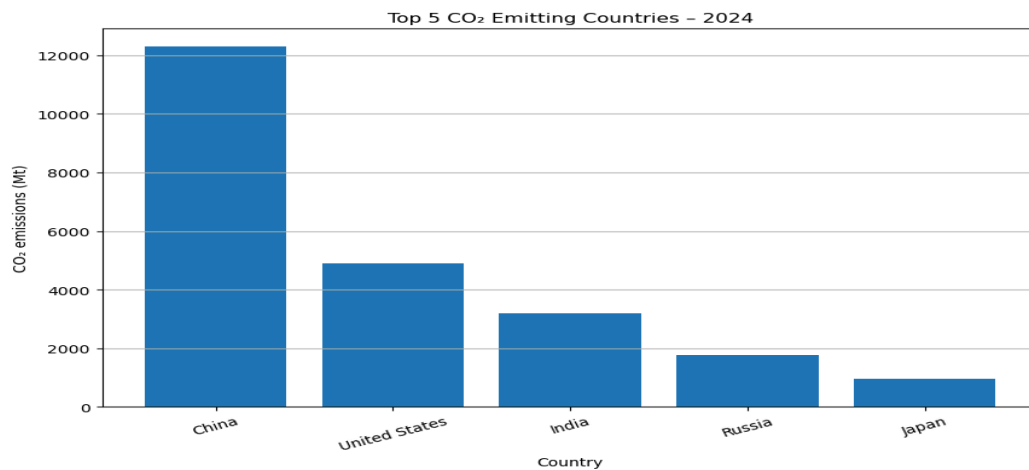
Insights

- China leads global emissions by a large margin (~12,289 Mt).
- The United States is the second-highest emitter (~4,904 Mt).
- India, Russia, and Japan also contribute significantly to global emissions.

Strategic Recommendations

1. Prioritize Low-Carbon Cloud Regions
• India has very high carbon intensity (708 gCO_2/kWh).
• Run AI workloads in cleaner regions (US/EU).
• Avoid compute-heavy jobs in high-carbon regions.
• Impact: 40–70% lower emissions for the same workload.

2. Optimize AI Model Training
• Prefer fine-tuning over full model training.
• Use smaller/distilled models when possible.
• Apply pruning, quantization, early stopping.
• Impact: Lower GPU hours, energy use, and cost.

3. Choose Cloud Providers with Strong Renewable Energy
• Select regions with high renewable penetration.
• Prefer providers offering hourly carbon-free energy.
• Review Google/AWS/Azure sustainability reports.
• Impact: Reduces operational emissions.

4. Use Carbon-Aware Scheduling
• Run non-urgent tasks during solar/wind peak hours.
• Use APIs for real-time carbon intensity.
• Impact: Lower emissions without changing regions.

5. Improve Hardware Lifecycle Efficiency
• Extend server/GPU lifespan.
• Reuse/repurpose hardware where possible.
• Optimize cooling systems.
• Impact: Reduces embodied carbon.

6. Track IT Carbon Emissions Regularly
• Set annual CO_2 budgets for AI & cloud.
• Use dashboards linked with cloud billing.
• Apply FinOps + GreenOps governance.
• Impact: Makes emissions measurable and accountable.