

# In-Depth Analysis: CO<sub>2</sub> Emissions from Industrial Combustion

## 1. Full-Series Trend (1970–2024): A Tale of Punctuated Growth

Emissions from Industrial Combustion have grown dramatically from ~63 Mt CO<sub>2</sub>eq in 1970 to ~689 Mt CO<sub>2</sub>eq in 2024, an 11-fold increase that establishes the sector as a cornerstone of India's emissions profile. However, unlike the smooth acceleration of the power sector, the story here is one of **punctuated growth**, with distinct periods of explosive expansion, surprising slowdowns, and aggressive rebounds.

## 2. Breakpoint Detection: Uncovering a More Complex Narrative

The analysis identifies three crucial breakpoints—**2004, 2015, and 2020**—that reveal a dynamic and shifting growth story. The piecewise regression model fits the data with near-perfect accuracy (Adjusted R<sup>2</sup> of 0.997), confirming that these regimes represent real structural changes in the sector.

The sequence of slopes for these regimes is [4.6, 29.6, 3.3, 35.1], and it tells a fascinating, non-linear story.

### Regime 1: 1970–2003 (Steady Industrialization)

- **Slope: 4.6**
- This initial, 34-year period represents the long, steady, but relatively slow growth of India's industrial base before the 21st-century economic boom.

### Regime 2: 2004–2014 (The Industrial Boom)

- **Slope: 29.6**
- The 2004 break marks an inflection point. The growth rate sextuples, launching the sector into a decade of unprecedented expansion. This aligns perfectly with India's manufacturing and industrial boom of the 2000s, driven by heavy industries like steel, cement, and chemicals.

### Regime 3: 2015–2019 (The Surprising Slowdown)

- **Slope: 3.3**
- This is the most unexpected and insightful finding. Following the 2015 break, the emissions growth rate **collapses by nearly 90%**, returning to a level even lower than the pre-2004 era. This suggests a significant industrial slowdown, a potential shift towards less energy-intensive industries, or the effects of energy efficiency and pollution control measures enacted

during this period. It marks a temporary but significant deviation from the high-growth trajectory.

#### Regime 4: 2020–2024 (The V-Shaped Rebound)

- **Slope: 35.1**
- The 2020 break is confirmed as **highly significant (p-value approx 0.0009)** by the Chow test. The subsequent slope is the **highest in history**, surpassing even the boom years. This indicates that the post-COVID recovery was not just a rebound but an explosive resurgence in industrial activity that completely erased the preceding slowdown and established a new, highly aggressive growth path.

### 3. Piecewise & ARIMA Insights: Confirmation of Volatility

The fluctuating slopes confirm that industrial emissions have not followed a simple path but have been highly responsive to economic shifts. The final regime is modeled as an **ARIMA(1, 2, 0)** process. The second-order differencing ( $d=2$ ) again points to a powerful underlying trend, suggesting the current high-growth phase has strong momentum.

### 4. Forecast & Future Implications

Driven by the aggressive post-COVID trend, the model forecasts emissions will reach **~1097 Mt CO<sub>2</sub>eq by 2034**. This represents a **~59% increase** from 2024 levels, indicating that the industrial sector remains on a steep upward trajectory.

### 5. Core Data-Backed Conclusions

- **Growth has been volatile, not steady:** Industrial emissions have been characterized by booms and slowdowns, making this sector's trajectory more complex than the power sector's.
- **The 2015–2019 slowdown was a real, but temporary, event.** While it offered a brief respite, it was not indicative of a long-term structural shift towards decarbonization. Understanding the specific economic drivers of this period is crucial for future policy.
- **The post-COVID industrial rebound is exceptionally strong.** It has set a new and concerning precedent for emissions growth, suggesting that economic recovery has been heavily reliant on carbon-intensive industrial activity.
- **Future growth is a major challenge:** The forecast indicates that, despite past volatility, the industrial sector is now firmly on a high-growth path that will significantly contribute to India's emissions over the next decade.