

In-Depth Analysis: CO₂ Emissions from Fuel Exploitation

1. Full-Series Trend (1970–2024): A “Boom-Bust-Boom” Cycle

Emissions from fuel exploitation (fugitive emissions from coal mining, oil, and gas operations) have increased nearly six-fold, from **~20 Mt CO₂eq** in 1970 to **~117 Mt CO₂eq** in 2024. Unlike the smoother curves of other sectors, this trend is marked by high volatility, with a distinct “boom-bust-boom” cycle that reflects shifting priorities in India’s domestic energy production strategy.

2. Breakpoint Detection: A Story in Four Volatile Chapters

The analysis identifies breakpoints at **1999, 2004, and 2009**, which deviate from the patterns seen in other sectors. These dates mark sharp reversals and highlight the sector’s sensitivity to policy and market conditions. The piecewise model fits the volatile data well (Adjusted R² of 0.985), and the slopes tell the story: **[0.9, 5.3, -2.1, 4.0]**.

Regime 1: 1970–1998 (The Long Stagnation)

- **Slope: 0.9**
- For nearly three decades, emissions from this sector grew very slowly. This reflects a long period of steady but unambitious domestic energy production.

Regime 2: 1999–2003 (The First Boom)

- **Slope: 5.3**
- The growth rate suddenly sextuples in this short, five-year burst. This suggests a concerted policy push to ramp up domestic coal, oil, and gas production at the turn of the millennium, likely to build strategic reserves and fuel the beginning of the economic expansion.

Regime 3: 2004–2008 (The Bust)

- **Slope: -2.1**
- In a dramatic reversal, the growth trend turns sharply negative. This is a critical insight, indicating a period where domestic exploitation activities either slowed significantly or implemented emission-reducing technologies (like coal mine methane capture).
- **Inference:** This “bust” period coincides with a time of extremely high global oil prices. It’s plausible that domestic production became less economically favorable compared to imports, or that policy shifted focus. This anomaly demonstrates that growth in this sector is not guaranteed and is highly sensitive to global market dynamics.

Regime 4: 2009–2024 (The Sustained Boom)

- **Slope: 4.0**
- The 2009 break marks a return to a strong, positive growth trajectory that has been sustained for the last 15 years. This signals a renewed and lasting policy focus on increasing domestic energy production (“Energy Security”). The Chow test confirms the 2020 break within this period is also **highly significant (p-value approx 0.00009)**, indicating the post-COVID rebound has reinforced this pro-production trend.

3. Piecewise & ARIMA Insights: Confirmation of a Return to Growth

The slope pattern confirms the “boom-bust-boom” narrative. The final regime’s **ARIMA(0, 2, 1)** model, with its second-order differencing ($d=2$), indicates that the current growth phase since 2009 has strong, persistent momentum.

4. Forecast & Future Implications

The forecast, based on the long-running current regime, projects emissions will reach **~158 Mt CO₂eq by 2034**. This represents a steady **~35% increase** over the next decade, reflecting the continued national emphasis on domestic fuel extraction.

5. Core Data-Backed Conclusions

- **A Volatile History:** This sector’s growth has been far from linear, defined by sharp policy or market-driven shifts rather than steady economic coupling.
- **The 2004-2008 “Bust” is a Key Anomaly:** This period of negative emissions growth is unique among the major sectors and demonstrates a high sensitivity to external market forces and import/export strategies.
- **A Sustained Push for Domestic Production:** Since 2009, the trend has been one of strong, sustained growth, signaling a long-term policy commitment to increasing domestic energy exploitation.
- **A Steady Contributor to Future Emissions:** While not growing as explosively as the power sector, the renewed focus on domestic production ensures that fuel exploitation will remain a significant and growing source of emissions.