

# In-Depth Analysis: CH<sub>4</sub> Emissions from Fuel Exploitation

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

Fugitive methane emissions from fuel exploitation (coal mining, oil & gas operations) have grown from **~31 Mt CO<sub>2</sub>eq** in 1970 to **~108 Mt CO<sub>2</sub>eq** in 2024. However, this overall growth hides the real story: a “tale of two eras.” The first two decades were marked by extreme volatility, with wild swings in growth, while the subsequent three decades have been a period of remarkable stability and slow, linear growth. The data is so erratic in the early years that even a sophisticated piecewise model struggles to capture its path perfectly (Adjusted R<sup>2</sup> of 0.81), highlighting the sector’s inherent unpredictability.

## 2. Breakpoint Detection: The Chaotic 1980s

The analysis identifies a cluster of early breakpoints at **1983, 1988, and 1993**. These dates confine the sector’s chaotic behavior to its early history and mark the transition to its modern, stable state. The slopes tell this story vividly: [**1.2, 7.4, -5.4, 1.2**].

### Regimes 1-3: 1970–1992 (The “Wild West” Era)

- **Slopes: 1.2 → 7.4 → -5.4**
- This period was the “wild west” for fugitive emissions. A short, explosive boom in the mid-1980s (slope of 7.4) was followed by an even more dramatic “bust” in the late 80s and early 90s, where emissions declined rapidly (slope of -5.4).
- **Inference:** This volatility likely reflects a period of unregulated expansion in coal mining and oil exploration, where production surges led to massive fugitive emissions, followed by downturns or the initial, haphazard implementation of flaring or capture technologies that caused sharp declines.

### Regime 4: 1993–2024 (The Long Stability)

- **Slope: 1.2**
- This is the defining characteristic of the sector’s modern history. Since 1993, the emissions growth rate has settled into a slow, steady, and predictable linear path, reverting to the same baseline slope as the pre-1983 era.
- **Inference:** This 31-year period of stability suggests the sector matured. Practices and technologies for controlling fugitive methane (such as improved mining techniques and gas flaring/capture) were likely standardized and widely adopted, preventing the runaway emissions seen in the 1980s. This has effectively “tamed” the growth of this potent greenhouse gas source, even as domestic fuel production has grown.

### 3. The COVID-19 Anomaly vs. The Long-Term Trend

While the Chow test identifies the 2020 dip and recovery as statistically significant, it does not appear to have knocked the sector off its long-term stable path. Unlike the CO<sub>2</sub> sectors, which jumped to new, steeper trajectories, fugitive methane emissions seem to have reverted to their predictable, slow-growth trendline after the shock.

### 4. Forecast & Future Implications

The forecast, based on the stable final regime, projects emissions will reach **~126 Mt CO<sub>2</sub>eq by 2034**. This represents a very modest **~17% increase** over the next decade. This is one of the slowest growth rates of any energy-related emissions source.

### 5. Core Data-Backed Conclusions

- **A Story of Tamed Growth:** The key narrative is the successful transition from a chaotic, high-growth-potential past to a stable, slow-growing present.
- **Technology and Regulation Likely Worked:** The 30-year stability strongly suggests that efforts to manage and mitigate fugitive methane emissions in India's energy production sector have been broadly and lastingly effective at preventing runaway growth.
- **A Hopeful Counterpoint:** While CO<sub>2</sub> emissions from fuel combustion have accelerated, the associated fugitive methane emissions have been kept in check. This provides a hopeful example of how targeted technologies and practices can successfully address a specific, potent source of greenhouse gas emissions.
- **Manageable Future Challenge:** The slow-growth forecast indicates that, while still requiring attention, fugitive methane from this sector is not an accelerating crisis and represents a manageable challenge compared to other emission sources.