In-Depth Analysis: F-Gas Emissions from Processes

1. Full-Series Trend (1970–2024): The "Hockey Stick" of a Modernizing Nation

Emissions of Fluorinated-gases (F-gases), used almost exclusively as refrigerants in air conditioners, refrigerators, and industrial cooling, tell a simple and powerful story. Their growth is a classic **"hockey stick" curve**: flat for decades, then exploding upwards in recent years. Growing from just ~**2.5 Mt CO2eq** in 1970 to ~**72 Mt CO2eq** in 2024, this trend is a direct proxy for the rise of India's middle class and the widespread adoption of cooling technologies. While the absolute total is still smaller than the major CO2 sectors, F-gases are one of the fastest-growing sources of emissions, and their high Global Warming Potential makes this trend particularly concerning.

2. Breakpoint Detection: The 2007 Inflection Point

The analysis identifies breakpoints at 1989, 1995, and 2007, but the story is really about the last one. The slopes are [**0.4, -0.4, 0.5, 3.5**].

Regimes 1-3: 1970–2006 (The Era of Insignificance)

- **Slopes: 0.4 → -0.4 → 0.5**
- For the first 37 years, F-gas emissions were negligible. The volatile, near-zero growth reflects a period when air conditioning and modern refrigeration were luxury goods available only to a tiny fraction of the population. The negative slope in the 1990s may reflect early compliance with the Montreal Protocol's phase-out of older refrigerants.

Regime 4: 2007–2024 (The Great Indian Cooling Boom)

- **Slope: 3.5**
- The 2007 break is one of the most significant inflection points in India's entire emissions history. The growth rate explodes by nearly **700%** and has remained high ever since.
- **Inference**: This marks the precise moment when rising incomes and aspirations made air conditioning and refrigeration mass-market consumer goods. This is the "AC Boom," and its impact on emissions is stark and undeniable. The COVID-19 dip in 2020 was sharp but temporary, as the fundamental demand for cooling remains a powerful, underlying driver of growth.

3. Forecast & Future Implications: A Critical Challenge Ahead

The forecast, driven by this powerful final regime, projects emissions will climb to **~107 Mt CO2eq by 2034**, a **~50% increase** in just ten years. This confirms that the "cooling boom" is still in its high-growth phase.

This trajectory highlights the critical importance of the **Kigali Amendment** to the Montreal Protocol, which India has ratified. This international agreement mandates a gradual phase-down of HFCs, the most common type of F-gas. The data shows the immense challenge that this policy is up against, as it must fight a tidal wave of consumer demand.

4. Core Data-Backed Conclusions

- **A "Hockey Stick" Trend:** F-gas emissions are defined by a dramatic and recent acceleration, beginning in 2007.
- **A Direct Proxy for Prosperity:** This trend is one of the clearest indicators of rising quality of life and disposable income in India, which makes it a politically and socially complex challenge to address.
- **One of the Fastest-Growing Threats:** In percentage terms, F-gases are one of the fastest-growing emission sources in the country.
- **A Test Case for Climate Policy:** The future path of this curve will be a direct test of the effectiveness of the Kigali Amendment and India's ability to transition its massive cooling industry to next-generation, climate-friendly refrigerants.