In-Depth Analysis: CH4 Emissions from Transport

1. Full-Series Trend (1970–2024): Mitigation, Reversal, and a Warning Sign

Methane emissions from the transport sector (a byproduct of incomplete combustion, particularly from certain engine types, and leaks from CNG/LPG vehicles) are a minor but highly informative emission source. Growing from just ~**0.1 Mt CO2eq** in 1970 to ~**2.4 Mt CO2eq** in 2024, the series does not show simple growth. Instead, it reveals a fascinating story of successful technological mitigation followed by a recent, sharp, and concerning reversal.

2. Breakpoint Detection: A Boom, a Long Lull, and a New Explosion

The analysis identifies breakpoints at **1990, 2000, and 2020**. The slopes tell a dramatic story of changing fortunes: [**0.01 → 0.08 → 0.03 → 0.16**].

Regime 1 & 2: 1970–1999 (The Initial Motorization Boom)

- **Slopes: 0.01 and 0.08**
- After two decades of negligible emissions, the 1990s saw a boom in methane emissions from transport, aligning with the first major wave of vehicle motorization in India.

Regime 3: 2000–2019 (The Era of Successful Mitigation)

- **Slope: 0.03**
- This is a critical insight. For two decades, the growth rate of methane emissions was **cut by more than half**, even as the number of vehicles on India's roads exploded.
- **Inference**: This strongly suggests that the introduction of progressively stricter vehicle emission standards (the Bharat Stage or BS norms, which began in 2000) and vast improvements in engine combustion technology were highly effective at controlling and reducing methane slip per vehicle.

Regime 4: 2020–2024 (The Great Reversal)

- **Slope: 0.16**
- The 2020 break is **highly significant (p-value** *approx* **0.0009)**. In the post-pandemic era, the growth rate has **exploded to its highest level in history**, nearly five times the rate of the previous two decades.
- **Inference**: This "Great Reversal" is a major warning sign. After 20 years of successful mitigation, something has changed. A likely candidate is the

massive policy push for Compressed Natural Gas (CNG) vehicles. While CNG produces less CO2 than gasoline or diesel, it is primarily composed of methane, and any unburned "methane slip" from the engine is a direct and potent greenhouse gas emission. This recent surge may be an unintended consequence of the otherwise positive shift to CNG.

3. Forecast & Future Implications

The forecast, driven by this new explosive regime, projects continued rapid growth. While the absolute numbers are small, this trend is concerning because it indicates that a key climate solution (CNG) may have a significant downside that is only now becoming apparent in the data.

4. Core Data-Backed Conclusions

- **A Story of Two Halves:** The history of transport methane emissions is one of successful technological mitigation from 2000-2019, followed by a dramatic and concerning reversal post-2020.
- **Emission Standards Worked:** The 20-year slowdown is strong evidence that vehicle emission standards were effective at controlling this specific pollutant.
- **A Potential Unintended Consequence:** The post-2020 explosion in the growth rate is a major red flag. It strongly suggests a link to the rapid expansion of the CNG vehicle fleet and requires urgent investigation to understand and mitigate the trade-off between lower CO2 and higher CH4 emissions.
- **A Warning Sign for Policy:** This sector serves as a crucial case study in how climate policy can have unintended consequences, and the importance of a holistic view of all greenhouse gases, not just CO2.