If India 100% Electrifies Its Transport Network,

What Is The Net Change in Carbon Emissions?

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Introduction

Electrification i.e. replacing technologies or processes using fossil fuels with electrically-powered equivalents (IEA, 2026a), has emerged as a major solution in the climate crisis. The World Economic Forum (Rémont, 2025) has discussed electrification at length, stating the process as a low-hanging fruit available to us for staving greenhouse emissions. Many countries worldwide have set electrification goals in different sectors as parts of their goals towards carbon neutrality and such.

India is no exception. As the world's third largest emitter, India aims to achieve carbon-neutrality by 2070; a mini-goal in this endeavour is electrification, mainly that of the transportation sector. Approximately 13% of India's carbon emissions come from the transport sector, out of which over 90% is road transportation (Kumar et al., 2022), and a significant chunk of recommendations for reducing the same involve electrification of some kind — subsidies for electric vehicles, strengthening policies for electrification, making the transition easier, EV financing support, etc. (IEA, 2023). While electrification is certainly a leap in the right direction, a few concerns do emerge.

Nearly 75% of India's electricity is generated through coal and coal-based products (IEA, 2026b). Therefore if one electrifies the entire transport sector, is there actually a net decrease in emissions? What quantity is this net decrease? Based on this, is electrification worth it or should efforts be redirected completely towards decarbonising the energy sector?

Process

First, let us quantify the impact of electrification. For this, I propose a model that understands electrification impact as a function of grid carbon intensity. This is an elementary model, focused on showing a relationship between emissions and grid carbon intensity. This model does not take undertake sensitivity analysis, and does not take into account factors such as grid-mix regional variation, vehicle efficiency, or any travel-pattern changes that may occur with electrification.

We shall assume grids of carbon intensity ranging from 0% to 90%, in order to better gauge intensity. We assume the grid carbon intensity remains constant as transport electrifies. That is, additional electricity demand is met by the existing generation mix. Under this assumption, electrification shifts emissions from tailpipes to the power sector rather than eliminating them outright, allowing us to estimate the net national change in emissions. Vehicle behaviour is assumed constant, reliant only on the energy mix, allowing us to isolate and gauge how grid carbon intensity governs effectiveness of electrified transport.

Net Emissions = Former Emissions - Former Transport Emissions + Electrified Transport Emissions

Transportation accounts for 13% of India's emissions. The average internal combustion engine emits 230gCO2/km (Negri & Bieker, 2025) and the average EV consumes 0.19kWh/km (EV Database, 2026). The electricity emission factors for coal-based electricity and clean electricity (average of nuclear, solar, hydroelectric, and wind) are 888gCO2/kWh and 41gCO2/kWh (WNA, 2011). In the final equation below, Electrified Transport Emissions is a function of grid carbon intensity. See Appendix A for the derivation and explanation.

$$\boxed{R = f\left(1 - \frac{\epsilon_{EV} G}{e_{ICE}}\right)}$$

Here, R denotes the fractional reduction in national emissions.

Results

By running this model, we get the following results (see Appendix B for code):

Grid Scenario	**Grid Intensity (gCO_2/kWh)**	**EV Emissions (gCO_2/km)**	**National Emissions Reduction (%)**
High Fossil (90%)	803.3	152.6	4.37
Current India (~75%)	676.2	128.5	5.74
Medium (50%)	464.5	88.3	8.01
Low (25%)	252.8	48.0	10.29
Fully clean (0%)	41.0	7.8	12.56

Insights

As transport makes up 13% of India's emissions, fully decarbonising the sector can reduce the country's emissions by 13% (assuming this share doesn't change) because of the sector's own bound. 13% decrease in emissions is still an extremely worthy goal. From the results it is clear that grid carbon intensity dictates carbon emissions by an electrified transport sector. The model suggests the EV policy and grid decarbonisation policy are complementary, not independent; the value of electrification compounds with improvements in grid carbon intensity.

Conclusion

Given the sheer scale of emissions, a ~6% decrease is noteworthy improvement. However, it is crucial to see that major emission savings actually would occur with an increasingly cleaner electricity grid (a difference of 8% with a fully electrified grid).

The model clearly displays that electrification of the transport sector is not the ultimate solution for decreasing transport emissions. As of now, complete electrification shifts a certain chunk of emissions from one sector to another (with some decrease, credit where it's due); this shift will decrease with a cleaner grid. The model shows that to deliver the complete benefits of electrification, the energy grid must be renewed and cleaned. Electrification on its own has benefits, but that benefit is complementary, it compounds when paired with a cleaner grid. As India slowly invests in clean energy, electrification will truly begin to make a major difference in the emissions picture.

References

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Appendix A: Model Derivation

Disclaimer: AI tools were used to assist in formulating the mathematical structure of the carbon payback model and generating the initial Python code for calculations. All assumptions, parameter choices, interpretation of results, and written analysis are of the author's. AI was used as a computational aid, not for generating any essay content.

Let:

- E = total national emissions
- f = fraction of emissions from transport sector
- e_{ICE} = emissions per km from internal combustion vehicles (gCO_2/km)
- ϵ_{EV} = electricity consumption per km (kWh/km)
- G = grid carbon intensity (gCO_2/kWh)

Initial transport emissions:

$$E_{transport} = fE$$

EV emissions per km:

$$e_{EV} = \epsilon_{EV} G$$

New transport emissions (assuming same distance traveled):

$$E_{transport}^{new} = fE \cdot \frac{e_{EV}}{e_{ICE}}$$

New national emissions:

$$E_{new} = E - fE + fE \cdot \frac{e_{EV}}{e_{ICE}}$$

Simplifying:

$$E_{new} = E \left(1 - f + f \cdot \frac{e_{EV}}{e_{ICE}}\right)$$

Fractional reduction:

$$R = 1 - \frac{E_{new}}{E} = 1 - \left(1 - f + f \cdot \frac{e_{EV}}{e_{ICE}}\right)$$

$$R = f - f \cdot \frac{e_{EV}}{e_{ICE}} = f\left(1 - \frac{e_{EV}}{e_{ICE}}\right)$$

Substituting $e_{EV} = \epsilon_{EV} G$:

$$\boxed{R = f\left(1 - \frac{\epsilon_{EV} G}{e_{ICE}}\right)}$$

This is the national emissions reduction as a fraction of total national emissions.

Appendix B: Python Code

```
import pandas as pd

# Transport share of national emissions
f = 0.13

# Vehicle characteristics
e_ICE = 230  # gCO2/km (average petrol/diesel)
ev_energy = 0.19  # kWh/km (average EV consumption)

# Electricity emission factors
G_coal = 888  # g CO2/kWh
G_clean = 41  # g CO2/kWh (renewables lifecycle approx)

# Grid scenarios (fraction fossil electricity)
scenarios = {
    "High fossil (90%)": 0.90,
    "Current India (~75%)": 0.75,
    "Medium (50%)": 0.50,
    "Low (25%)": 0.25,
    "Fully clean (0%)": 0.00
}

results = []

for name, fossil_share in scenarios.items():
    G = fossil_share * G_coal + (1 - fossil_share) * G_clean
    e_EV = ev_energy * G

    reduction = f * (1 - e_EV / e_ICE)
    reduction_percent = reduction * 100
```

```
    results.append([name, round(G,1), round(e_EV,1),
                   round(reduction_percent,2)])

df = pd.DataFrame(results, columns=[
    "Grid Scenario",
    "Grid Intensity (gCO2/kWh)",
    "EV Emissions (gCO2/km)",
    "National Emissions Reduction (%)"
])

print(df)
```