Freight transport transition pathways in India: Mitigation and development

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Abstract

Burgeoning freight transport demand driven by high economic growth target and road sector dominance in modal mix can have wide-ranging ramifications on achieving sustainable development goals and carbon neutrality targets for India. Fossil-fuelled freight transport accounts for nearly 42% of the total petroleum fuels consumption and 80% of this demand is met through imports. CO_2 emissions and $PM_{2.5}$ pollution from vehicular exhaust, and the consequent negative externalities underline the urgency to investigate the low-carbon transitions pathways for freight sector. In this paper, we undertake a comprehensive analysis to determine the implications of low-carbon transitions in freight sector on environment, energy systems and economy. We use a back-casting method based on the long term benchmarks, and soft-couple the economy-wide IMACLIM-IND and techno-economic AIM/Enduse models to derive the long term pathways. Our narratives include extensive details on socio-economic, technological and behavioural transformations for four scenarios business-as-usual (BAU), road freight focussed (FROAD), technology and modal shift

(TRAIL) and harmonized multimodal transport (HMML). We follow an iterative approach, combining qualitative storylines at local, national and global level with related quantitative drivers, to determine policy-relevant pathways which reconcile the long term strategies with medium and short term action.

Goods ranging from food to medical supplies are carried by road in India. The inter-regional goods transport in urban areas, constituting mainly consumer products and foods, are distributed by road transport that essentially falls under the unorganized sector mired in inefficiencies. Rail mode transports certain bulk commodities such as coal, iron ore, construction material and fertilizers. Past trends (from 1978-2008) reveal that while the average freight traffic lead has declined for rail from 810 km to 661 km, it has increased for road from 353 km to 453 km (National Transport Development Policy Committee) that upholds the current shift towards road in India. We assume 6% CAGR of GDP for our period of analysis from 2013-2050 in all scenarios. Further, COVID-19 brings down the annual average growth rate of logistics sector in the near term, however it rises back to 7% rate by 2030. The long term benchmarks are based on the multiple sources such as extant literature, and experts' and stakeholders' inputs.

Our BAU scenario follows the broad framework outlined in Nationally Determined Contributions (NDCs) submitted by India in the Paris Climate Change Agreement, 2015. It assumes improvement of emission intensity of all modes in freight transport, and construction of Dedicated Freight Corridors (DFCs) and highways. 2-wheelers play a critical role in providing last-mile connectivity in e-commerce sector in urban and rural areas. FROAD scenario assumes that freight mobility per unit economic output increases compared to BAU driven by the growth in e-commerce sector and 'Make in India' programme, however the mobility growth gradually slows down by 2050. The mobility demands till 2050 are primarily met through road mode even for certain bulk commodities with high volume but low value.

‘Bharatmala’ project of Ministry of Road Transport and Highways improves the road connectivity in this scenario through the development of economic corridors, expressways, highways, port connectivity roads and feeder roads. Further, it assumes significant reduction in imported crude oil demand by adopting biofuels, enhancing vehicle efficiency norms and electrification. Arid land in the country is used to grow biofuel crops which provides the co-benefits of improving the farmer’s income and employment rate. FROAD scenario assumes 20% biodiesel blending with diesel and 5% ethanol blending with petrol by 2030. The feedstock for biofuels is derived from bagasse, industrial waste, municipal solid waste, agricultural or forestry residues and used cooking oil. Mainly, technology advancements and modal shift towards rail define our TRAIL scenario that assumes significant reduction of CO_2 emissions from freight transport to facilitate the attainment of net zero emissions target for Indian economy in the second half of the century (IPCC report on “Global Warming of 1.5^{o}C”). It assumes an increase in share of rail from the current 36% to 48% by 2030, and electrification of road freight transport such that the major source of power is non-fossil fuels. The use of alternative fuels such as hydrogen increases by 2050 and the behaviour of firms shifts towards the adoption of greener transportation modes. Additionally, this scenario uses technologies such as roll-on-roll-off, RoadRailer, containerization and double stack dwarf trains, and assumes DFCs on all freight routes across the country. Inland and coastal navigation plays a larger role compared to BAU in this scenario. It is likely that the freight cost per unit mobility may increase significantly compared to BAU due to high investment cost of developing technology and related infrastructure, however we impose restriction on the cost of the system so as to maintain the accessibility of logistic services to small and medium enterprises. HMML scenario follows a balanced approach harmonizing the twin goals of reduction in imported fuels and carbon emissions that can assist in achieving development and decarbonisation targets simultaneously. It assumes the implementation of

multi-modal logistics parks across India, electrification, and increase in share of biofuels. Intermodal connectivity facilitates convenience, speed and timely delivery thus encouraging companies to shift to greener transportation modes.

We find that our HMML scenario reduces CO_2 emissions from freight by more than 80% compared to BAU by 2050. It reduces the dependence on imported fuel by 70% thus inducing foreign exchange savings that can be used to offset developmental expenditure. Our results show that envisioned transitions necessitate the shift to multi-modalism and electrification in freight transport, driven by higher investments in infrastructure and technology development. In such a scenario, the policies need to reconcile the conflicting interests of various players such as diesel truck drivers and logistics service providers, and thus facilitate the ‘just’ transition to electric vehicles, railways and waterways. In addition, international funding can play a critical role in achieving decarbonisation in freight sector by 2050.