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Developing Fit-for-purpose Analytical Tools to Support Transport Sector Decarbonisation in LMICs

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Summary

When attempting to make decisions regarding alternative low-carbon development pathways for the transport sector, modelling tools can be of enormous benefit by providing analysis and creating scenarios.

Several models have been developed around the world, but these are primarily orientated towards OECD countries, and so are less well-suited to representing transport sector realities in low- and middle-income countries (LMICs). To be fit-for-purpose, models for LMICs need to reflect the distinctive characteristics of their transport sectors (for instance informality) and the policy needs of each country.

The models need to be calibrated with appropriate parameter values (such as longer vehicle lives), provide a level of detail commensurate with limited local data availability, and ideally build on open-source software to reduce cost and promote accessibility. While some progress has been made in adapting transport sector models to LMICs, no transport sector model currently available fully meets all these criteria. CCG with its partners is working towards the development of such tools.

Key Policy Recommendations

- The international community should prioritise the development of modelling tools that are fit-for-purpose in supporting LMICs to identify suitable transition pathways for the decarbonisation of the transport sector. A collaborative approach that aligns stakeholders around a standard open-source modelling tool, coupled with an in-country training programme, is likely to have the greatest impact.
- A promising approach would be to build upon recent successful experiences in Kenya and Costa Rica to develop a model that can provide a flexible and adaptable representation of the transport sector, while remaining compatible with the wider ecosystem of energy modelling tools along the investment pipeline.
- Sector modelling tools are only useful to the extent that reliable data sources are available to support them. This underscores the importance of ongoing efforts, such as the Transport Data Commons Initiative (TDCI) and Asian Transport Outlook (ATO) Data, to expand and improve the availability of foundational sector data for transport in LMICs.
- Once such models are available, there will be a pressing need for broad-based capacity-building efforts to equip policymakers and academics in LMICs with the knowledge and skills to develop their own future transport scenarios using accessible tools and localised data. These can leverage established capacity-building channels, such as CCG's Energy Modelling Platform.

Introduction

Worldwide, the transport sector accounts for 24 percent of greenhouse gases and is one of the fastest growing sources of carbon emissions. While per capita transport-related carbon emissions remain low in low- and middle-income countries (LMICs), aggregate emissions are growing relatively quickly. At the same time, mobility remains constrained in many LMICs and improved transport has a vital role to play in social and economic development. Moreover, beyond carbon emissions, transport imposes many other significant social costs, including local air pollution, traffic congestion, and road safety.

The decarbonisation process for the transport sector is relatively complex and less understood compared to other high-emitting sectors, such as electricity generation. Several factors complicate the analysis of transport sector decarbonisation. Transport is organised such that different institutions are responsible for the provision of infrastructure (such as roads) versus transport services (such as buses), typically cutting across national, regional, and local jurisdictions. Transport services operate in parallel modes (for instance road and rail), often with competing public and private providers within each mode. Transportation is a highly decentralised activity that reflects independent behavioural choices made by a huge number of individuals and firms.

Importance of transport modelling tools

Given this complexity, policymakers and financiers need modelling tools to be able to evaluate the Paris alignment of alternative future transport scenarios and simulate the impact of alternative policy and financing options. A significant number of models and modelling frameworks have been developed for the transport sector, often nested in a wider energy context. These include LEAP (SEI), MESSAGE (IIASA/IAEA), Mo-Cho-TIMES (UC Davies), Mo-Mo (IEA), PASTA (ITF), Roadmap (ICCT), and TEAM (University of Oxford). Some of these models are based on optimisation paradigms that minimise the cost of meeting transportation demand, while others operate instead as simulation tools that can illustrate the impact of implementing specific policy measures. While both have their place, the decentralised nature of the transport sector makes simulation a particularly valuable approach, given that there is no central planner optimising the system. Models also differ in their granularity and ability to assess other impacts beyond carbon emissions.

Such modelling tools are typically deployed in the context of specific futures, which are usually best developed through an iterative process of stakeholder engagement in the country. For any given scenario, models (or the wider ecosystem in which those models exist) should ideally be able to do the following things: estimate the capital and operating costs of the transport system, calculate the fiscal implications of changes in the flow of tax revenues and subsidy expenditures from transport, project the carbon emissions (and potentially other environmental impacts) associated with each scenario, and estimate the economic benefits associated with any selected pathway.

Criteria for an LMIC-appropriate transport model

Nevertheless, existing tools typically developed in an OECD context are not generally suitable for -deployment in LMICs. Transport sectors in LMICs differ substantially from those in the OECD, and these differences (such as low motorisation rates, high share of informal transport, and heavy reliance on second-hand vehicle markets) need to be reflected in the structure of models. Moreover, underlying model parameters (such as demand elasticities, modal choice, vehicle efficiency, or occupancy ratios) often reflect realities in OECD countries. Calibrating models to better reflect LMIC environments calls for significant data collection efforts.

As part of a collaboration with the Asian Development Bank, CCG recently conducted a review of established transport and transport-energy modelling tools, encompassing engagement with over a dozen stakeholders representing major worldwide modelling institutions. This suggests that an LMIC-appropriate transport model should meet the following four criteria [1]. A full comparison of existing modelling tools against these criteria is provided in Table 1.

1. **Level of detail:** The structure of the model must be such that transport sector-specific phenomena can be represented mathematically, including modal choice, vehicle choice, freight demand growth, fuel prices, etc.
2. **Data requirements:** The structure of the model must be sufficiently adaptable, such that the level of detail can be adjusted according to the level of data availability in a local context.
3. **Visualisations and user interface:** The model must have an in-built visualisation suite and user interface, such that it is easy to use for someone who is not trained in programming.
4. **Open source:** The model must be open source, such that it is adaptable, trainable, and suitable for deployment across institutions in different geographies without the need for purchasing individual licensces. Note that this is not the same as open access, which implies free and open access to a proprietary code base.

Modelling tool/ framework	Institution	Level of detail	Data requirements	Visualisation/ user interface	Open source
LEAP	Stockholm Environmental Institute	✔	✔	✔	✖
OSeMOSYS	KTH Sweden	✖	✔	✔	✔
MoMo	International Energy Agency	✔	✔	✔	✖
Roadmap	ICCT	✔	✔	✖	✖
TEAM	UK Energy Research Centre	✔	✖	✖	✖
MESSAGE-Transport	IIASA	✔	✖	✖	✖
2050 Calculator	Imperial College London	✖	✖	✔	✖
EFFECT	World Bank	✖	✖	✔	✖
MoCho-TIMES	Denmark Technical University	✔	✖	✖	✖
PASTA	International Transport Forum	✔	✖	✔	✖

Table 1 Assessment of transport and transport-energy modelling tools against four key criteria defining LMIC-suitability

This comparative analysis underscores that none of the models currently available meet all four of the criteria. Nevertheless, some recent examples of transport model adaptation to LMIC environments provide useful lessons and indicate part of the way forward.

Kenya Case Study: Adapting TEAM

TEAM (Transport Energy Air pollution Model) is a strategic systems model, covering a range of transport-energy-environment dimensions. Originally developed for use in the UK,TEAM has been significantly revised by CCG with the aim of adapting it for use initially in Kenya, with the possibility of broadening applications to other LMICs later. The first complete LMIC application of the model in Kenya entailed major efforts in primary data collection for model calibration and in programming adjustments to reflect structural differences in vehicle fleets. Extensive stakeholder engagement was also undertaken to define relevant future scenarios. While TEAM-Kenya has proved capable of delivering a rich representation of LMIC transport futures [2], the relatively data-intensive and time-consuming nature of the modelling process, as well as the absence of an open-source software foundation, suggest that further work is needed before this approach becomes suitable for major scale-up.

Costa Rica Case Study: Building on OSeMOSYS

OSeMOSYS is a flexible open-source energy modelling framework, which incorporates a high-level representation of the transport sector, primarily focusing on how to meet shifting energy demand resulting from climate transition, such as fleet electrification or greater reliance on hydrogen. A recent application for Costa Rica illustrates the scope for building additional transport sector detail into OSeMOSYS, through the enrichment of a plug-in transport module [3,4]. This entails incorporating a more detailed disaggregation of the vehicle fleet, plus computation of externalities (not only carbon emissions but also local air pollution, road safety, and congestion), and a representation of the associated fiscal regime on transport fuels. While less detailed than TEAM in its representation of the transport sector, this approach potentially offers advantages in terms of relatively easy scalability as well as interoperability with other modelling tools [5] along the investment pipeline [6], but this would require further improving and enhancing the transport module for OSeMOSYS. Such an approach is being explored initially for Lao PDR and Vietnam in partnership with the Asian Development Bank.

A way forward

The global community does not yet have an entirely fit-for-purpose transport sector modelling tool for LMICs that can support both policymakers and financiers with the development of low-carbon transport pathways. Given the urgency of low-carbon development, and the complexity of transport sector decarbonisation, there is a pressing need for partnership between research institutions and international organisations to produce a suitable customised modelling tool. Moreover, aligning efforts across stakeholders around a standard open-source model for transport sectors in LMICs is likely to bring greater development impact than a proliferation of proprietary tools. The efficacy of such a model should be further enhanced through continued effort to improve the availability of transport sector data, together with a major capacity-building effort to empower policymakers and academics in LMICs to develop their own low-carbon development pathways.

References

[1] Dixon, J. and H. Dalkmann, 2023. Low Carbon Development Pathways in Transport Systems: A comparative analysis of available transport-energy models and modelling approaches. Report.

[2] Dixon, J. et al., 2023. How can emerging economies meet development and climate goals in the transport-energy system? Modelling co-developed scenarios in Kenya using a socio-technical approach. [Preprint under review in Energy Strategy Reviews]

[3] Godínez-Zamora, G. et al., 2020. Decarbonising the transport and energy sectors: Technical feasibility and socioeconomic impacts in Costa Rica, Energy Strategy Reviews, Volume 32, 100573, ISSN 2211-467X, https://doi.org/10.1016/j.esr.2020.100573.

[4] J. Quirós-Tortós and L. Victor-Gallardo, "The Bigger Picture: Robust Decarbonization of the Transport Sector in Costa Rica," in IEEE Power and Energy Magazine, vol. 21, no. 6, pp. 77-90, Nov.-Dec. 2023, doi: 10.1109/MPE.2023.3308234.

[5] Tan, N., Vrochidis, I., Luscombe, H., et al. (2023). Data to Deal: developing an energy modelling analytical workflow to enhance political and financial decisions. Preprint.

[6] Luscombe, H., Foster, V., Howells, M., Quiros-Tortos, J., and Jaramillo Gil, M. Data-to-Deal: An Emerging and Effective Approach to Supporting Countries in Climate Transition. Climate Compatible Growth Programme COP28 Policy Brief Series. Available at: https://climatecompatiblegrowth.com/wp-content/uploads/Data-to-Deal-COP28-Policy-Brief.pdf.

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