Transport-energy modelling in sub-Saharan Africa:

innovations and opportunities to support informed policymaking towards equitable, clean access for all

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Supporting non-motorised transport (walking, wheeling and cycling) can help achieve many social, economic and environmental goals, including improved access; improved air quality; improved safety and reduced cost of urban infrastructure.

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SUMMARY

An effective transport system provides equitable, clean access to goods and services. Transitions towards this shared goal entail co-evolution between industry, technology, markets, policy, culture and civil society. System models and analytical tools provide a useful quantitative backdrop in building policy, project and investment pipelines towards realising this goal.

Due to the unique challenges shared by the majority of sub-Saharan African (SSA) states, including their heavy dependence on imported second-hand vehicle markets, the dominance of popular transport for serving passenger travel demand and chronic data availability constraints, the application of High-Income Country (HIC)-based transport-energy models to SSA contexts tend to offer only vague approximations to local dynamics. Innovative approaches are needed to develop models to support informed decision-making given these challenges.

In this policy brief, we:

1. Set out the **challenges** faced by SSA countries in developing fit-for-purpose system models and analytical tools to support decision makers towards equitable, clean access for all;
2. Detail **innovations** to meet these requirements, given the unique and persisting challenges, and identify **opportunities** present to enable these innovations; and
3. Set out a **framework** for the development of SSA context-appropriate system models and analytical tools to support transport-energy transitions towards equitable, clean access.

POLICY RECOMMENDATIONS

- **A concerted international effort should be supported to pursue the development of context-appropriate system models** to support decision-makers in building robust transport-energy pathways towards the sustainable development priorities of SSA countries. This should be formally recognised as part of the UN Decade of Sustainable Transport, starting in 2026.
- **SSA research institutions must be properly funded** for their essential involvement in the co-development of context-appropriate transport-energy system models. Co-development must be co-ordinated with capacity building efforts to improve the understanding and usability of models for local decision-makers, which should include the development of SSA university curricula to build local expertise in the field.
- **Innovations in data collection and model formulations must be developed and supported** with the aim of overcoming common data availability constraints in SSA countries. Data efforts should be sustainably funded – e.g. in collaboration with multilateral development banks – to gather, adapt and leverage new and restricted data.
- **Models and scenarios must be co-produced with local decision-makers** and stakeholders from the start to attune with local priorities, maximising their application, usability and impact. **Models, scenarios and data efforts must cover Gender, Equality and Social Inclusion (GESI) aspects** by involving and consulting relevant decision makers and representatives on those issues.

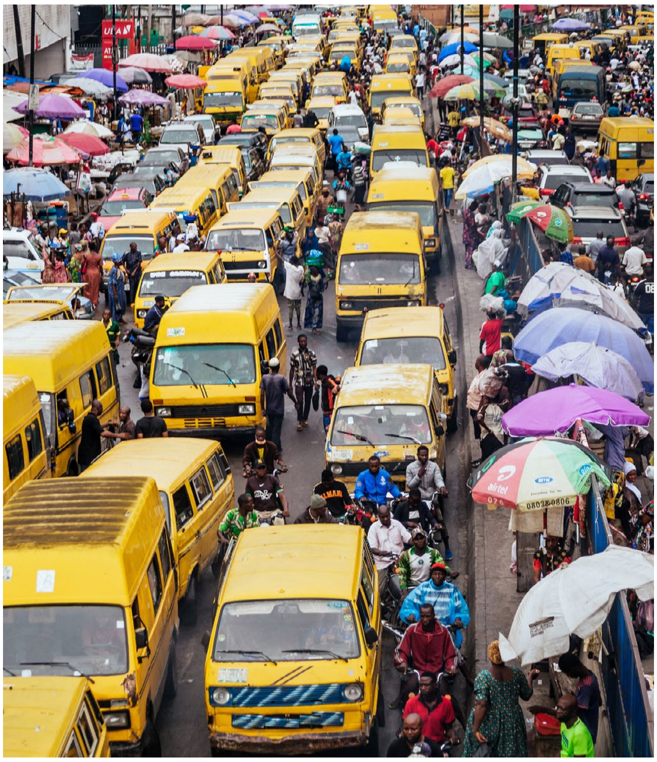
1 INTRODUCTION

Whole energy system models are used as decision-support tools by governments and other stakeholders to develop policy, project and investment pathways to support clean economic growth (see e.g. [1]). Traditionally, however, the transport system in these models is simplistically represented, often as an end-user of energy. This does not allow for detailed analysis necessary in building pathways towards equitable, clean transport futures.

Whilst transport challenges and suitable innovations are highly diverse across geographies, there are several shared factors across the majority of sub-Saharan African (SSA) countries. Such shared factors include the prevalence of second-hand vehicle imports, the dominance of popular (a.k.a. informal) transport modes and chronic data availability constraints. Furthermore, the end goals are often different: whilst much of the present-day focus in high-income countries (HICs) is on decarbonisation, per-capita emissions in SSA countries are generally much lower, and thus emission-reduction targets are diminished relative to other challenges. Improved air quality, reduced road casualties and improved access to fundamental services are often of greater importance, whilst ensuring that emissions are kept low into the future (and avoiding lock-in to polluting and increasingly uncompetitive technologies [2]).

Therefore, by building on greater understandings of SSA transport system characteristics towards context-specific scenario development, it is necessary to consider not only the energy system implications of transport futures and their adequacy for vehicle electrification and motorisation growth rates, but other externalities of transport (e.g. road safety and air pollution) and the impact of these transport futures on the distribution of access amongst populations.

The consideration of sustainable economic development, including but far from limited to climate mitigation, is particularly crucial when modelling transport-energy systems in SSA contexts. Wider metrics that address UN Sustainable Development Goals (SDGs) include access to goods and services enabled by affordable mobility, economic opportunities provided by freight transport, public health outcomes resulting from transport systems and job creation resulting from new industry growth in a low-carbon transition. The need for infrastructure must also be considered, including transportation infrastructure and surrounding systems needed to support transitions, such as clean electricity systems for vehicle electrification.



Popular (a.k.a. informal) services supply the majority of passenger travel in SSA cities. How will this mode evolve as part of the future of SSA transport systems?

The transport system is socio-technical, in that its outcomes are a function of interactions between society and technology [3]. Therefore, we propose that socio-technical modelling approaches (see e.g. [4]) can be used to (i) represent transport system phenomena more realistically than centralised optimisation models often used in whole energy systems analysis, and (ii) inclusively involve stakeholders in the scenario development process. These approaches reject the notion of 'one-size-fits-all' solutions that are based solely on technology and are therefore capable of producing contextually aware and specific transition envelopes.

In this policy brief, we set out a direction for the future of transport-energy modelling to inform better policy making in SSA countries. We set out the shared challenges and look at the direction of travel under the status quo. We develop a set of innovations to address these challenges and, based on these innovations, we establish a framework for the development of transport-energy models that can inform policy, supporting clean, equitable access for all.

2 SHARED TRANSPORT CHALLENGES IN SUB-SAHARAN AFRICAN COUNTRIES

Although transport system challenges are unique to local geographies, there are a set of challenges shared by the majority of SSA states. Figure 1 depicts some of these main challenges, broken down into four categories: infrastructure, social justice, services and governance.

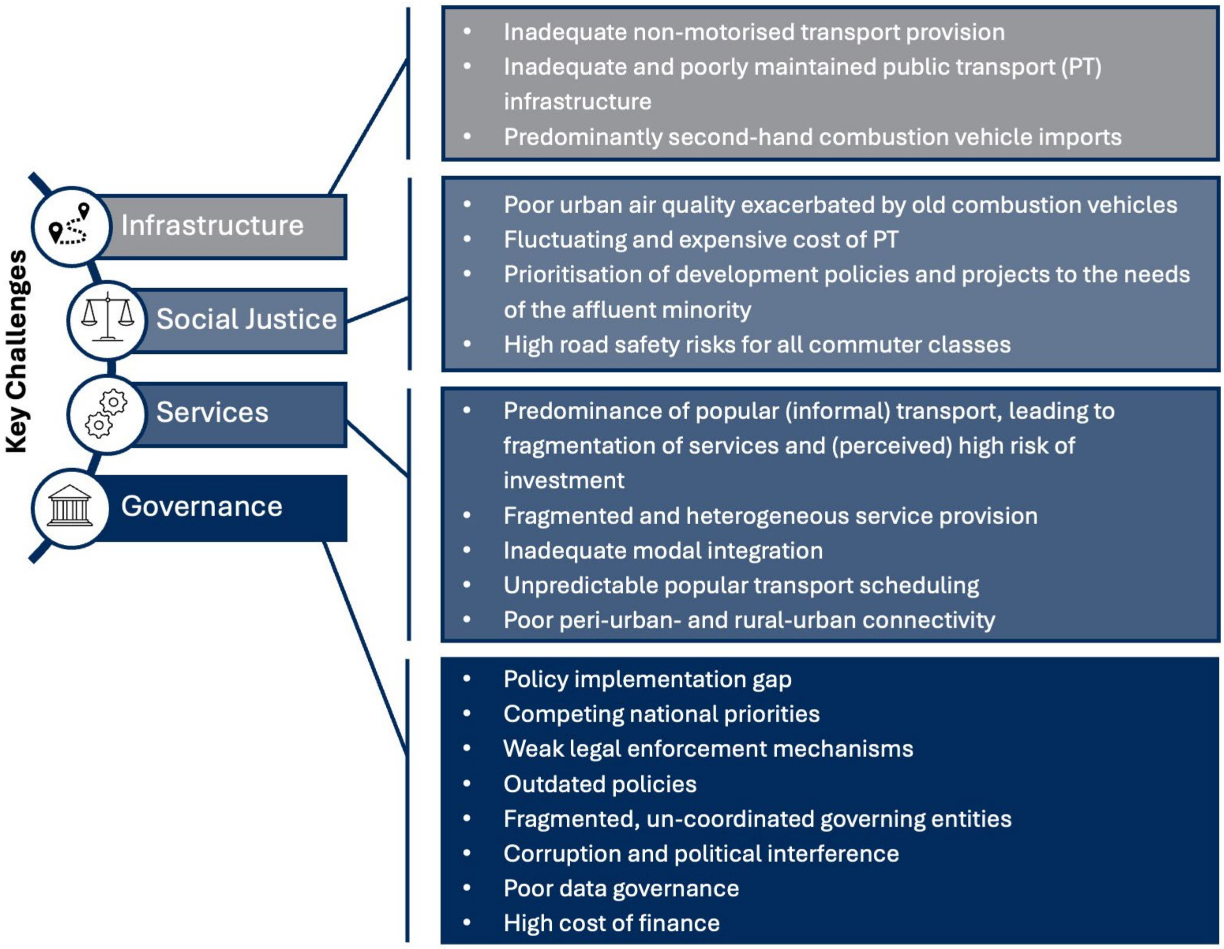


Figure 1 Key shared challenges across SSA transport systems

3 INNOVATIONS TO IMPROVE THE STATUS-QUO

SSA countries have so far largely been left out of transport-energy transition modelling exercises conducted worldwide, thus limiting opportunities for development and impairing their ability to engage meaningfully in global discussions on climate and energy ambitions [5]. Specifically, many of the challenges identified in Figure 1 introduce constraints that currently render modelling in SSA countries overly reliant on the use of proxies that offer only vague approximations to local dynamics [6]; furthermore, such approaches are often designed through other value lenses with little reflection of local priorities [5].

In Figure 2, we present a set of 'worst outcomes' arising from the status quo (left), and a set of plausible innovations (right) to circumvent the challenges identified, thus producing scenario modelling that can support policymakers in realising clean, equitable transport futures.

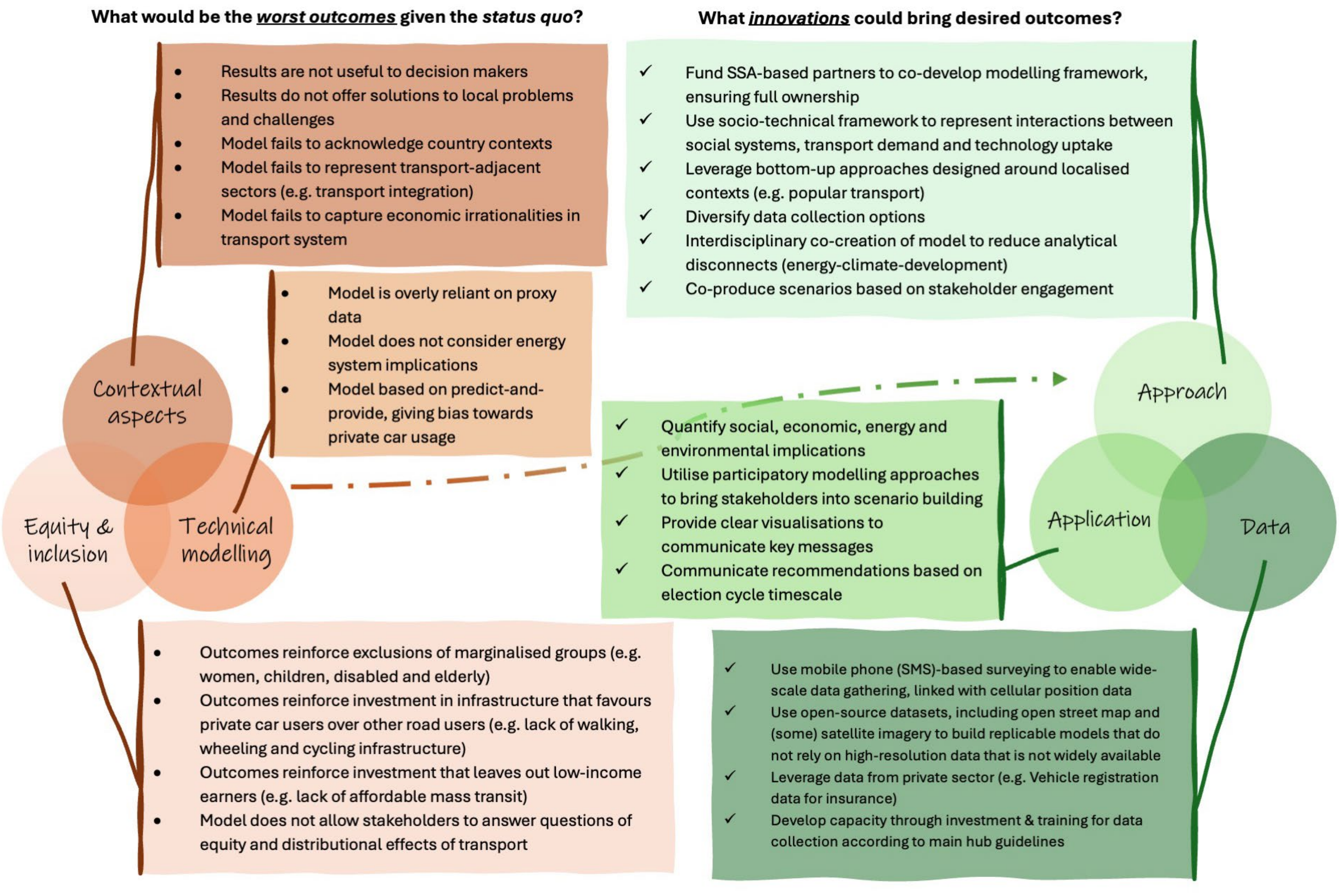


Figure 2 SSA transport-energy modelling 'worst outcomes' based on business-as-usual trajectories, and plausible innovations to improve status-quo

4 A FRAMEWORK FOR THE FUTURE: socio-technical approaches to transport-energy modelling in sub-Saharan Africa

Based on the innovations for data, approach and application in Figure 2, we present a framework for the development of transport-energy modelling to support the development of pathways towards clean, equitable access in SSA countries.

This framework, shown in Figure 3, sets out the objectives, levers, methods and outputs of useful transport-energy system models for SSA contexts. Figure 3 does not necessarily map to the development of a single modelling tool; instead, a set of integrated tools (as per the approach in [7]) may be required to address the objectives highlighted.

To progress the further development of this framework and the ultimate realisation of context-appropriate transport-energy modelling tools for SSA countries, we propose the following next steps:

1. **Develop a well-connected research network** of SSA-based transport-energy modellers and analysts that can work collaboratively on shared challenges and joint initiatives, including global modelling and scenario-building collaborations and the development of curricula for SSA universities to build capacity in the field.
2. **Co-produce a broad cache of relevant situational dimensions** – necessary for effective socio-technical approaches – using co-creational workshops held between research institutions, governments and other key actors, thus improving the usability and eventual uptake of modelling tools.
3. **Develop and strengthen national government data collection capacity,** initiating public-private partnerships to aid this effort whilst implementing best data management practices and ensuring open-source "FAIR" principles guaranteeing data findability, accessibility, interoperability and reusability.
4. **Establish, and coordinate funding pool** to support SSA institutions' meaningful contribution to global research activities, build capacity and integrate use of modelling tools as key pieces of evidence for informed policymaking.

Motorcycles are the most common vehicle type in many East African countries including Kenya, Rwanda and Uganda. Often used as moto-taxis for passengers and freight, they are amongst the easiest vehicles to electrify. What will the impact of motorcycle electrification be on the rest of the energy system?

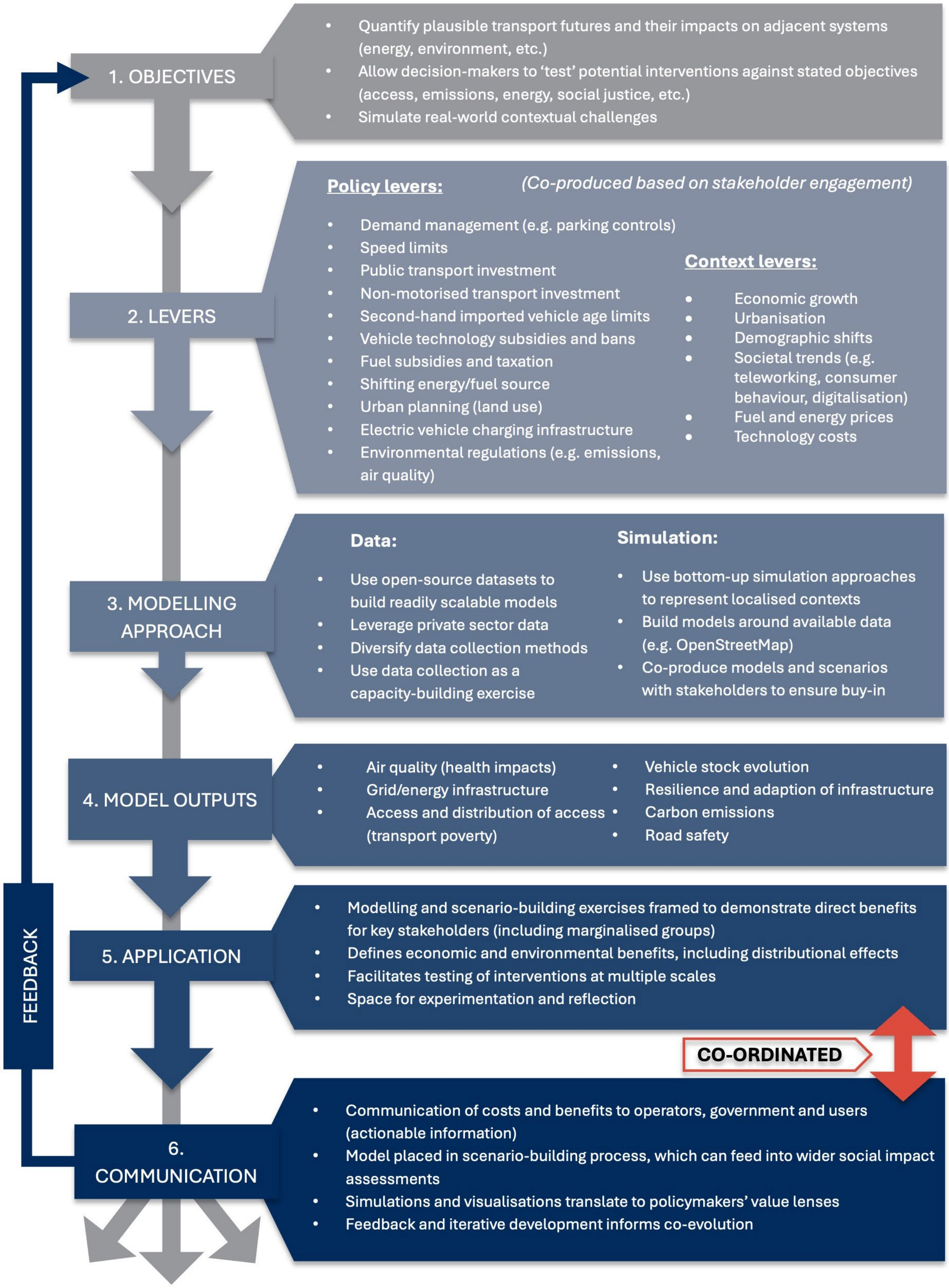


Figure 3 Socio-technical framework for the development of SSA-appropriate transport-energy modelling tools

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This policy brief was developed based on an expert workshop held in October 2024 at the University of Strathclyde, featuring representatives from eight universities and government institutions, representing six SSA countries: Kenya, Ghana, Zambia, Malawi, South Africa and Rwanda (Figure 4).

Figure 4 In-person workshop on transport-energy modelling for sub-Saharan African contexts at the University of Strathclyde, Glasgow, October 2024

REFERENCES

[1] G. Godínez-Zamora et al., "Decarbonising the transport and energy sectors: Technical feasibility and socioeconomic impacts in Costa Rica," Energy Strategy Reviews, vol. 32, p. 100573, Nov. 2020, doi: 10.1016/j.esr.2020.100573.

[2] G. C. Unruh, "Understanding carbon lock-in," Energy Policy, vol. 28, no. 12, pp. 817–830, Oct. 2000, doi: 10.1016/S0301-4215(00)00070-7.

[3] F. W. Geels, "A socio-technical analysis of low-carbon transitions: introducing the multi-level perspective into transport studies," J Transp Geogr, vol. 24, pp. 471–482, Sep. 2012, doi: 10.1016/j.jtrangeo.2012.01.021.

[4] J. Dixon et al., "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," Energy strategy reviews, vol. 53, pp. 101396–101396, May 2024, doi: https://doi.org/10.1016/j.esr.2024.101396.

[5] R. M. Mutiso, "Net-zero plans exclude Africa," Nature, vol. 611, no. 7934, pp. 10–10, Nov. 2022, doi: 10.1038/d41586-022-03475-0.

[6] M. O. Dioha, L. Duan, T. H. Ruggles, S. Bellocchi, and K. Caldeira, "Exploring the role of electric vehicles in Africa's energy transition: A Nigerian case study," iScience, vol. 25, no. 3, p. 103926, Mar. 2022, doi: 10.1016/j.isci.2022.103926.

[7] H. Luscombe et al., "Data-to-Deal (D2D): An Emerging and Effective Approach to Financing the Climate Transition," 2024, Cambridge. doi: 10.33774/coe-2024-21xv4-v3.


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