MODELLING SUSTAINABLE ENERGY PATHWAYS FOR LAND TRANSPORT IN NIGERIA

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Overview

Nigeria is the largest economy and the most populous country in Africa. Road is the major mode of motorised transport in the country. It accounts for over 90% of both passenger and freight movements in terms of km travelled [1]. The energy demand of Nigerian transport has been varying over the years and has increased at a compound annual growth rate (CAGR) of 3.68%, from 166 PJ in 1990 to around 368 PJ in 2012[1]. The Nigerian transport sector is dominated by gasoline and diesel [2]. Nigeria is also not exempt from the negative impacts of fossil fuel-based transport that the world is facing. Many Nigerians, especially those living in traffic congested cities like Lagos and Port Harcourt are exposed to air pollution which contributes to cardiovascular and respiratory diseases and this exacerbates poverty in the country. Despite the challenges facing Nigerian transport, the sector is not without ambition. In recent years, the FGN has shown its commitment to implement policies and strategies to develop a safe, secure, affordable, and sustainable transport system in the country. It developed the National Energy Masterplan (NEMP) which outlined many programmes for the transport sector. However, the design of any transport policy needs to be informed by quantitative assessments which takes into account the impacts of low carbon pathways on the energy system. The primary aim of this study is to investigate the energy system implications of different low carbon development strategies for the Nigerian transport sector. Specifically, this research paper seeks to:

- construct a bottom-up energy system model for the Nigerian transport sector
- examine the future trend of transport energy demand for alternative policy pathways
- examine the implications of alternative transport scenarios on environmental emissions

Methods

Energy modelling and scenario analysis are the commonest methods for energy policy analysis. In this paper, we calibrate a new transport energy model for Nigeria based on the TIMES (The Integrate Markal-EFOM System) modelling framework. TIMES was developed in a collaborative program under the guidance of the International Energy Agency's (IEA) Technology Systems Analysis Program (ETSAP). TIMES is multi-period bottom-up partial equilibrium model generator for sectoral, local, national, multi-regional, or global energy system. It uses an optimisation algorithm and assumes a perfect foresight to provide a least-cost energy system based on several user-defined constraints (e.g. resource availability, technology penetrations, emissions cap etc). TIMES is a data-intensive model and the user is required to provide data on the energy supply resources and technologies as well as on the available and future stock of energy demand technologies. To successfully calibrate a model based on TIMES modelling framework, the user is required to provide the following category of data: global assumptions, energy service demands, energy carriers, energy demand and supply technologies, and environmental emission factors. A more elaborate description and documentation of the TIMES model is given in Ref [3]. We took data from secondary literature and experts' opinion to calinbrate the TIMES-Nigeria-Transport (TINITRANS) model. Our model accounts for both passenger and freight movements in Nigeria. We then use the model to explore different low carbon pathways for the transport sector based on the NEMP. Our scenarios are named: Reference (REF); Fuel/technology switching (FTS); Improved fuel economy (IFE); Modal shift (MDS); Logistics improvement (LDT), and Carbon tax (CTX) scenarios.

Results

In the REF scenario where there is no significant technological changes, final energy demand is expected to increase at a CAGR of 5% from 346 PJ in 2010 to around 1270 PJ and 2439 PJ in 2030 and 2050 respectively; i.e. 2.7 and 6 times increases in 20 and 40 years respectively. Comparing results of the low carbon scenarios to the REF case, our analysis indicates that final energy demand of the FTS scenario will decrease by 138 PJ in 2050, which is equivalent to 5.7% reduction in comparison with the REF case. Analysis of the IFE scenario results show that final energy

[1]https://www.iea.org/statistics/index.html?country=NIGERIA&year=2016&category=Energy%20supply&indicator=TPESbySource&mode=table&dataTable=BALANCES

demand is projected to fall by 168 PJ in 2030 and 1044 PJ in 2050; these values correspond to 13.2% and 42.8% reductions respectively, compared to the REF scenario. The results of the MDS scenario analysis indicate that the final energy demand is projected to decrease by 193 PJ in 2030 and 657 PJ in 2050; representing 15.2% and 26.9% reductions respectively when compared with the REF case. With better logistics and adequate transport management in Nigeria as per the LDT scenario, our analysis of model results shows that final energy demand, in comparison to the REF scenario, is projected to drop by around 175 PJ and 290 PJ in 2030 and 2050 respectively. These values also represent 13.8% and 11.9% energy savings relative to the REF case. Finally, our analysis of the CTX scenario where the impact of introducing a carbon tax was considered shows that final energy demand is expected to fall by 141 PJ in 2030 and 331 PJ in 2050—11.1% and 13.6% reductions respectively, compared to the REF scenario. To advance our understanding of the scenarios, the combined (CMB) scenario was constructed to study the energy system impacts of implementing all the policies considered here (i.e. REF scenario minus the total energy savings in the low carbon scenarios). In doing this, carbon tax was excluded as it's not part of the policies enshrined in the NEMP. Analysis of the results suggest that the final energy demand of the CMB scenario is projected to decrease by 534 PJ in 2030 and 2129 PJ in 2050 compared to the REF case; these values also represent 42.1% and 87.3% reductions respectively, compared to the REF scenario. With respect to CO_2 emissions, for the REF scenario, the model results indicate that CO_2 emissions are expected to grow at a CAGR of 5% from 24.1 $MtCO_2$ in 2010 to around 88.8 $MtCO_2$ in 2030 and 170 $MtCO_2$ in 2050 which is about 2.7 and 6 times increases in 20 and 40 years respectively. In the alternative scenarios, similar pattern of emission reductions were observed as in the case of final energy demand. The co-benefits due to the sustainable energy transition scenarios in the Nigerian transport sector are also analysed. The modelling results indicate that the low carbon pathways will enhance air quality, energy security, and productivity of energy use within the country. While the modelling results indicate significant energy savings and CO_2 mitigation potentials due to low carbon strategies, we argue that a coordinated, sound, clear, and coherent policy framework, coupled with strong political commitments are needed for sustainable energy transition of the Nigerian transport sector.

Conclusions

In view of our objectives, the following conclusions may be drawn. Realising sustainability goals in Nigeria transport will involve structural and demand-side policies that can support technological innovations for improved fuel economy and alternative fuel development. It will also require strong political will and serious transformative actions from the local communities to the federal government levels. These transformative actions will require massive investments in public transportation and non-motorised means such as walking and cycling in order to reduce private car use. It will also require Nigerians to move away from the car-centric mentality attitude to people-centric mentality. Dedicated efforts will also be required over the upcoming years as there will be societal barriers and limited institutional capacities in the low carbon transition agenda. Additionally, we can infer that sustainable development of Nigerian transport will require the implementation of aggregated or portfolio of policies as well as regulations that enhance efficient movement of people and goods without a corresponding impact on the environment. Given the multiplicities of actions required, a successful transition needs to be communicated effectively in policy discourse if meaningful progress is to be made in the transport sector.

References

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