Impact of Electrification and Biofuel Use on Carbon Emission Reduction Potential

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Overview

With a quarter of total global carbon dioxide emissions coming from transport energy use, there are roughly three options to reduce emissions – reducing transport energy demand, improving vehicle fuel efficiency, replacing mobility fuel with low-carbon varieties such as biofuel and electricity (Lam et al, 2018). This paper estimates the carbon emission reduction potentials of using biofuel in road vehicles, as a complementary strategy to increasing electrified vehicles in India, Indonesia and Thailand.. Detailed Wheel to Wheel analysis is done India, Indonesia, and Thailand which have set ambitious targets to electrify the transport vehicles . The simulation results indicate that a moderate electrification strategy alone is not sufficient to reduce carbon emissions to the level required by 2030, and a moderate to aggressive electrification combined with hybrid-promotion would have a maximum impact. The complementary use of both the conventional and next generation biofuels, as a substitute for transport fuel demand, will have total net positive carbon reduction and economic benefits.

Methods

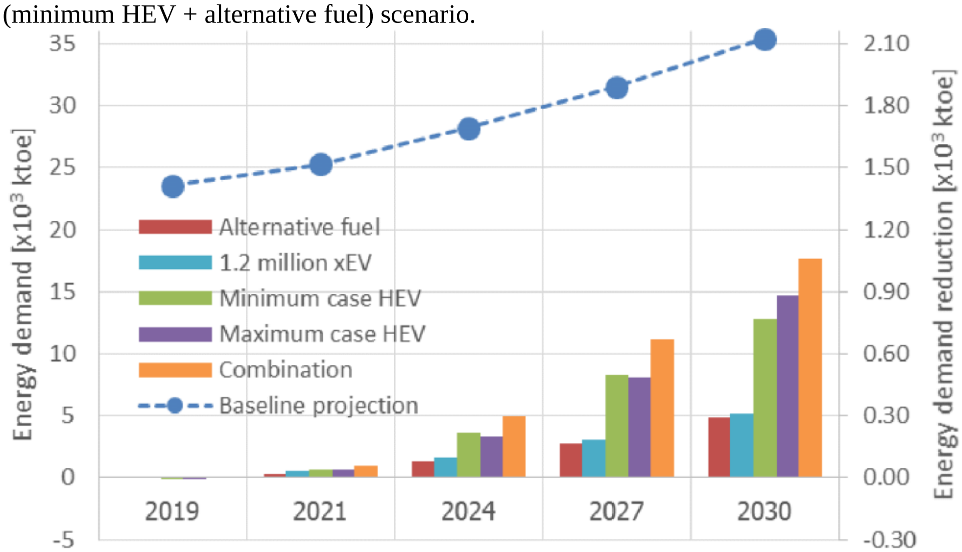
The energy consumption trend of road transportation , both passenger and freight vehicles. during 2015–2030 was simulated by using an Energy , developed by Toyota Motor Corporation, which is based on the International Energy Agency/Sustainable Mobility Project (IEA/SMP) Model. Well-to-tank (WtT) and tank-to-wheel (TtW) CO_2 emissions factor of each type of fuel are estimated based on based on approach proposed by Zhang et al (2018) . Country's specific data such as vehicle fleet, fuel use, and current mileage travelled annually from the published reports and national statistics . The information on transport policy, alternative fuels including biofuels, Electric Vehicles (EV) policy, amongst others, were also collected from the literature national stastics. The following assumption are made to see the total cost of decarbonization until the target year of 2030, (a)Higher vehicle costs for EVs compared to Internal Combustion Engine (ICE) vehicles (compared to ICE vehicles, HEVs 126%, PHEVs 146%, and BEVs 200% including home charger) (b) Infrastructure cost required depending on the progress of specific type of vehicle introduction (fast charging station of US$58,500 per 10 units for BEV/PHEV and CNG stations of US$1.8 million per 1,000 units for CNG vehicles) and (c) The total fuel cost used by all the vehicles in the market, including newly introduced vehicles.

Results

The model application and simulation results in India shows that that the increased deployment of CNG-fuelled vehicles across various vehicle categories and enhanced use of alternative fuels manifests itself by way of a marginal decline in the total final energy demand in the AFS to 122.1 million tons of oil equivalent (Mtoe) (0.41% reduction from BAU) by 2025 and to 154.4 Mtoe (0.64% reduction from Business As usual by 2030. In the electrification centric scenarios, a marginal increase of final energy demand is observed compared to the BAU scenario. Even with aggressive EV adoption the well-to-wheel CO_2 emission levels are higher than the BAU scenario, implying that with the existing electricity generation mix, EVs alone cannot bring down the emission levels. Although the electrification scenarios show reduction in tank-to-wheel CO_2 emissions, indicating if additional electricity demand for EV is met through electricity generated from renewables, it would result in CO_2 emissions reduction. The total tank-to-wheel (TtW) CO_2 emissions will be more than double, increasing from 247 $MtCO_2$ in 2015 to 463 $MtCO_2$ by 2030 in the BAU scenario registering a CAGR of 4.27%. In the AFS, the increased share of CNG-fuelled vehicles in the road transport fleet and enhanced use of alternative fuels results in WtW CO_2 emissions reduction to 412 $MtCO_2$ by 2030 translating into 11.1% reduction from BAU levels in 2030.

As per the simulations in Indoensia, the Total WtW CO_2 emissions will more than double, increasing from 256 Mt-CO_2 in 2015 to 626 Mt-CO_2 by 2030 in the BAU scenario, registering a 6.1% compound annual growth rate (CAGR). In the AFS, the increased share of CNG-fuelled vehicles in road transport fleets and enhanced usage of alternative fuels results in reducing WtW CO_2 emissions to 608 Mt-CO_2 by 2030, translating to a reduction of 3% reduction from the BAU level in 2030. This implies that the gains from the reduction in aggressive electrification are more than offset by slow improvements in fuel efficiency and less uptake of CNG-fuelled vehicles and alternative fuels. It also illustrates that road transport electrification as a policy lever for reducing CO_2 emissions is effective only with deep decarbonisation of the power sector. In terms of vehicle technology, in the BAU scenario, HCVs are seen to contribute about 36% of CO_2 emissions by 2030, which can be attributed to the large percentage of fossil fuels they consume, followed by buses with 18.2%, and cars and jeeps with 15.4%; three-wheelers are observed to account for the lowest amount of CO_2 emissions by 2030, with a share of only 4%.

Figure1 shows energy demand in the transport sector for BAU and five scenarios in Thailand. xEV technology (plug-in xEVs or hybrid expansion scenarios) can help reduce total energy demand. Two HEV scenarios are more effective for the reduction of energy demand. The most effective scenario to reduce energy demand is the combination (minimum HEV + alternative fuel) scenario.



HEV = hybrid electric vehicle, ktoe = , xEV = electrified vehicle.

Figure 1 Energy Demand in the Decarbanised Transport Sector for Scenarios in Thailand

From the viewpoint of fossil fuel consumption from imports, the alternative fuel scenario is better than the introduction of xEVs, including HEVs. In this case, the most effective scenario to reduce fossil fuel consumption is the combination (minimum HEV + alternative fuel) scenario.

The cost of implementing Electric Vehicles depends on the fuel cost, vehicle cost, and infrastructure cost. It is evident from the model results that the infrastructure cost when compared to the other two costs is quite low. However, the infrastructure development should account for the availability of parking space for charging stations within city limits as the majority of the metropolitan cities face parking space constraints. The charging time also makes a significant difference as even the fast charging stations require a minimum of 20 minutes to attain full charge, which is more than the time taken in traditional fuel stations. This in turn adds to the infrastructure cost in terms of land required. The vehicle and fuel costs determine the effectiveness of EV introduction

Conclusions

In countries with high GHG emissions from power generation, such as India, Indonesia and Thailand, the introduction of xEVs alone cannot reduce emissions levels. First, it is necessary to promote power generation by using renewable energy, and in parallel with this, promote the introduction of xEVs.The scenarios on decarbonization choices demonstrates that electrification scenarios alone do not have much effect in reducing the CO_2 emissions levels. The use of alternative fuels such as CNG and biofuels in road transport will play a crucial role as the CO_2 emissions levels are highest for HCV and buses. The electrification of HCV and buses will be a major challenge as they operate for longer distances. The battery size required for these vehicles is demanding and dedicated efforts are required to develop charging infrastructure along important routes and highways to quell the range anxiety. Their transition towards cleaner fuel along with improved fuel efficiency will strengthen the impact of EVs introduction for carbon emissions reductions. The policy strategy should consider both electrification as well as alternative fuels at the same platform to boost its impact.

References

Lam, A.; Lee, S.; Mercure, J.-F.; Cho, Y.; Lin, C.-H.; Pollitt, H.; Chewpreecha, U.; Billington, S. Policies and Predictions for a Low-Carbon Transition by 2050 in Passenger Vehicles in East Asia (2018) : Based on an Analysis Using the E3ME-FTT Model. Sustainability, 10, 1612

Zhang, R., Fujimori, S., Dai, H., Hanaoka, T.,(2018). Contribution of the transport sector to climate change mitigation: insights from a global passenger transport model coupled with a computable general equilibrium model. Appl. Energy 211, 76–88.