Decarbonising land transport in Micronesia: a case for electric vehicles

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Land transport is a major sector of liquid fuel consumption and energy expenditure in the Pacific, often dominating total national expenditure (Santagata et al., 2021). As shown in Figure 1, energy use in transport is determined by vehicle operation, infrastructure, demand, and industry structures, all of which are associated with energy consumption drivers such as vehicle efficiencies, infrastructure services, fuel prices, and interconnectivity. Acting on these factors can contribute to reduced fuel consumption and decarbonisation in the Pacific. Electric vehicles (EVs), in particular, have significant potential to assist with decarbonisation and reduce liquid fuel dependence in the Pacific (UNESCAP, 2019). This short study aims to provide a brief situational analysis of the land transport sector in the Federated States of Micronesia (FSM) and investigate some EV integration scenarios under a variety of electrification and renewable energy (RE) mixes. Given its maritime character, fuel dependency, and ambitious climate goals, FSM is an excellent example to gauge the benefits of fuel switching with electricity as a strategy towards decarbonisation, energy self-sufficiency, and economic development in Pacific Island Countries and Territories (PICTs).

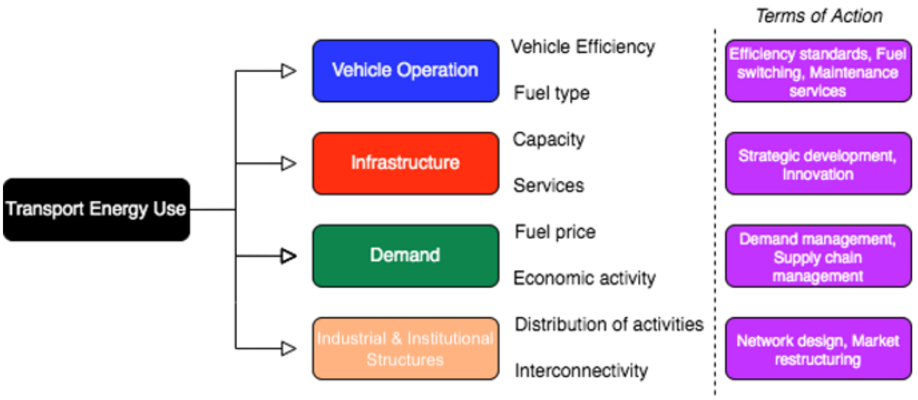


Figure 1. Energy use, consumption factors, and terms of action in land transport.

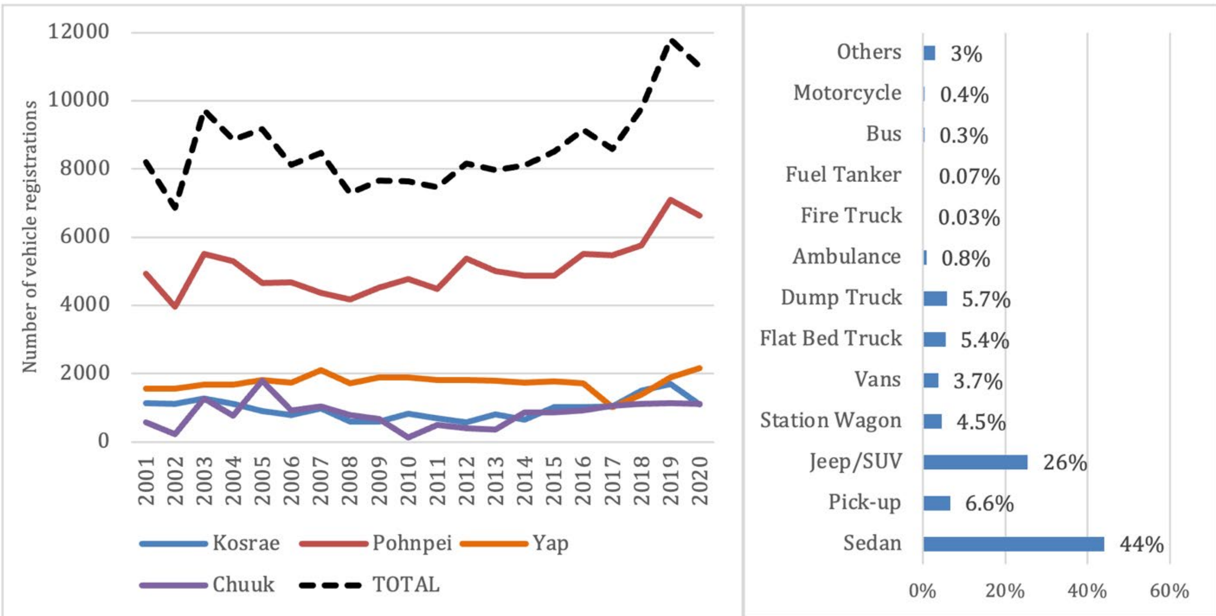
Context: Land Transport in FSM

The Federated States of Micronesia (FSM) consist of a group of 4 island states (Yap, Chuuk, Pohnpei, Kosrae) with a total of 600 islands and 115,000 inhabitants. Its GDP is roughly 410m US$. The majority of land transport infrastructure is concentrated on the main state islands – with a total estimated national road network length of 500 km (47% sealed, 53% unsealed) (FSM, 2021, DLCA, 2018, PRIF and SPC, 2021). Table 1 provides further details regarding roads in each state. Smaller outer islands have very few roads and inhabitants rely on small walking trails to travel. There is also no form of railway transport. The national Department of Transportation, Communications & Infrastructure (DTCN&I) is responsible for road maintenance. The heavy equipment required to carry out these activities is available for the most part, except in Chuuk state, although high fuel costs and logistic complexity tend to restrict maintenance activities (DLCA, 2018).

In 2020 there were roughly 11,000 registered vehicles in FSM, with most being second-hand imports from Japan. Figure 2 shows both the national and state trends of vehicle registrations, as well as the latest fleet composition in terms of vehicle type. Discontinuities in the number of vehicle registrations most often indicate de-registration of vehicles after a short usage period, which often results in vehicle abandonment (Rehman, 2015). This often happens due to the lack of well-equipped repair shops, spare parts, and regulations regarding vehicle disposal. Discontinuities may also be due to inconsistencies in data registries, for which inaccurate inputs and inconsistent updates are typical (Vukikomoala and Etuati, 2022).

Table 1. Summary of road networks in FSM.

State	Total Road Length (km)	References	Comments
Pohnpei	320	(FSM, 2021)	This covers all the main, feeder, and arterial roads throughout the main Island of Pohnpei. Sealed roads are mostly in good condition. Several small unsealed peripheral roads serve various villages and provide access to the coast. One bridge is unsafe.
Chuuk	60	(DLCA, 2018, PRIF and SPC, 2021)	38 km of unsealed or degraded sealed roads in bad condition on Weno. 12 km of unsealed road on Fefen. 10 km of unsealed road on Tonowas. Bridges are in good condition.
Yap	60	(PRIF and SPC, 2021)	40 km of sealed roads, 10 km double seal roads, and 10 km of unsealed roads. Roads in either good condition or under repair. Three bridges are unsafe.
Kosrae	60	(DLCA, 2018, PRIF and SPC, 2021)	30 km of sealed roads and 30 km of unsealed roads. Mostly in fair condition, with exception of Southern and South-Western sides of the island, where roads are 4WD access. Bridges are in good condition.
TOTAL	**500**	(road density of 71.23 $km_{roads}/100km_{land}^2$)	



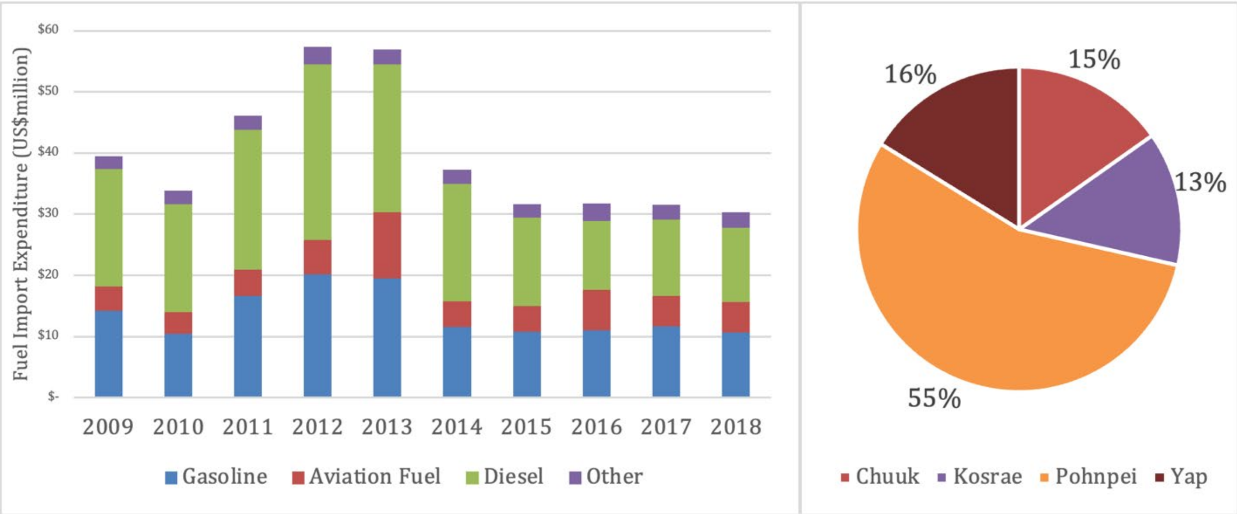
Source: Department of Public Safety (2010-2020), FSM Transport and Communication Statistics Division (2001-2009)

Figure 2. Vehicles registrations in FSM.

Energy consumption and efficiency targets in FSM are outdated (FSM, 2012), having expired in 2020 with no specific progress reports or outcomes published. Regarding emissions, a national target prescribes a mandatory 28% reduction in emissions by 2025 against 2000 levels, with a conditional 35% target upon adequate support (FSM, 2015). Emissions reductions are to take place in electricity generation and transport. However, there are no sectoral emissions or energy targets for transport.

Liquid Fuel Consumption

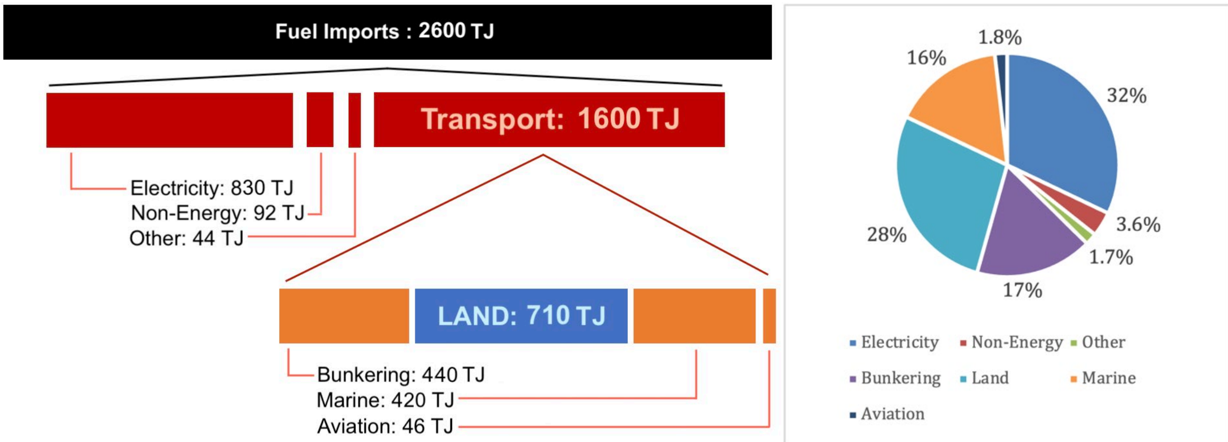
All vehicles in FSM depend on liquid fuels. Fuels are imported via Guam by the FSM Petroleum Corporation (FSMPC), a government enterprise which has been the sole fuel distributor for all 4 states since 2008. The 2 main supply routes via Guam respectively cover Kosrae, Pohnpei, Chuuk, and the Marshall Islands, Yap and Palau. Figure 3 displays expenditures for imports related to fuels in the whole of FSM as well as the proportion of each state's contribution. Gasoline and diesel respectively contribute 35% and 46% to fuel-related imports. All states except Chuuk spend more on diesel than gasoline on average. Total transport emissions are in the order of 100,000 tCO2e (WRI, 2015).



Source: 2018 FSM International Merchandise Trade Statistics

Figure 3. FSM fuel-related imports, state percentages, and sector consumption.

Figure 4 provides a high level visualisation of FSM's fuel demand. Total fuel imports are roughly 2600 TJ, which corresponds to 94% of the total energy supply (Naderi, 2022). It is shown that about 27% of imported fuels are destined to land transport, compared to an average of 33% for the Pacific (Santagata et al., 2021). A considerable amount of transport in FSM is conducted by marine vessels due to its maritime character.



Source: UN Energy Balances 2018, (Naderi, 2022)

Figure 4. Fuel imports and demand in FSM.

Electrifying Land Transport with different Generation Mixes

The electrification of the land transport fleet in FSM is assessed in terms of its impacts on required added electricity to serve EVs, emissions reductions, and fuel import reduction (both physical and economic). The constructed model is deterministic and assesses these metrics using the latest data available for vehicle registrations, fleet composition in terms of fuel type (diesel or petrol), fuel efficiencies for various vehicle types, typical distances travelled, and typical emissions (scope 1 and 3). Fleet composition and annual travelled distances are the parameters with most uncertainty. The assumptions underlying this model are summarised in Table 2.

Table 2. Model assumptions.

Assumption	Reference
Fuel Prices | Petrol 1.18 US$/L, Diesel 1.42 US$/L. Fuel Energy Content | Petrol 32.04 MJ/L, Diesel 36.9 MJ/L. Fuel Emissions | Petrol 2436 gCO2/L, Diesel 2911 gCO2/L.	(Naderi, 2022)
Fleet composition is assumed to be the same as Fiji (82% petrol, 18% diesel). Hybrids are not considered. Light duty and heavy duty commercial vehicles all run on diesel. Heavy and light duty commercial vehicles (HCV, LCV) run on diesel. Motorcycles on petrol.	(UNESCAP, 2019)
Categories | Cars: Sedan, Other. Heavy Cars: Pick-up, Jeep/SUV, Station Wagon. LCV: Vans, Flat Bed Truck, Ambulance. HCV: Dump Truck, Fire Truck, Fuel Tanker. Taxis are not considered in this study.	Arbitrary.
Fuel | Cars consume 7.6 and 6.5 L/100km for petrol and diesel respectively. Heavy cars 13 and 9.1 L/100km. LCV 8.9 L/100km. HCV 37 L/100km. Buses 35 L/100km. Motorcycles 2.7 L/100km..	(Grütter and Kim, 2019)
Electricity | Cars consume 0.17 kWh/km. Heavy cars 0.2 kWh/km. LCV 0.185 kWh/km. HCV 1.3 kWh/km. Buses 1.14 kWh/km. Motorcycles 0.04 kWh/km.	(Grütter and Kim, 2019, Tesla, 2022)
Cars and heavy cars travel 15,000 km annually. LCV 17,000 km. HCV 22,000 km. Buses 65,000 km. Motorcycles 7,000 km. Distances based on reported data and adjusted to balance energy consumption.	(Grütter and Kim, 2019, UNESCAP, 2019, Naderi et al., 2022)
Diesel genset produces 3.5 kWh/L. Renewable generation costs and emissions are not considered and are assumed to be negligible.	(Santagata et al., 2021)

A total of 9 EV integration scenarios are considered, across 3 cases of EV uptake (100%, 50%, 25% of fleet), each with 3 cases of generation mix (100% RE, 50% RE, 100% Diesel). The non-renewable portion of the generation mixes is assumed to be entirely constituted of diesel gensets, which are a common electricity generation source in the Pacific (Wolf et al., 2016, Naderi, 2022). Figure 5 summarises the results obtained from the model (Scenarios S1-9), shown in terms of additional electricity required, fuel import reductions (in absolute and relative terms), and emissions reduction. It is found that transitioning to EVs reduces fuel consumption regardless of the generation mix, thus reducing annual fuel expenditure (between 700k US$ and 22m US$) and emissions (between 3500 and 55,000 tCO2e) across all scenarios. This is promising for the Pacific due to their fuel-intensive economies. Additional electricity generation requirements range between 12,000 and 50,000 MWh annually – which roughly correspond to 5 and 20% of current electricity production respectively.

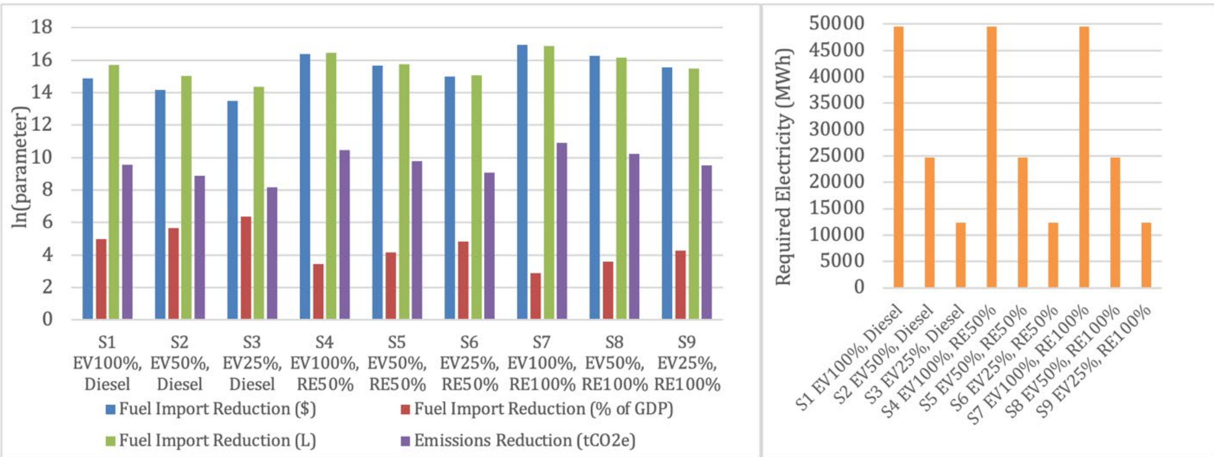


Figure 5. EV integration scenarios and model results (log normalised, except MWh).

Conclusions

This short study has demonstrated that EVs are an excellent option for decarbonisation in FSM, as fuel-related operational costs and emissions are greatly reduced. Some challenges in achieving this transition include poor technical and institutional capacity, and a lack of policy, including specific targets. This could be supported by better modelling with reduced uncertainty in estimating transitions costs and better vehicle usage data. Marine transport electrification should not be overlooked, as it contributes substantially to transport fuel demand. Future studies could contribute by refining assumptions based on new national data and integrating capacity expansion models, transition pathway scenarios with specific transition timelines, strategic vehicle implementations (e.g. more electric bikes with lower infrastructure costs), capacity building program strategies, considerations regarding equity issues and the second hand market, and feasibility assessments. While still in need of refinement, this model may also be applied to other PICTs.

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