Republic of the Marshall Islands Energy Future

Electricity Roadmap

Technical Note 09: Electrification of Transport

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Summary

This technical note documents the assumptions made about new electricity loads which result from the potential future uptake of electric transport in RMI. It does not analyse the overall trends in transport use or develop strategies for reducing emissions from transport (which should be carried out as much-needed separate piece of work). The purpose of this document is only to provide an estimate of electricity load resulting from electrification of transport.

The assumption used for the RMI Electricity Roadmap techno-economic analysis was that an uptake of electric transport would add 2 GWh to annual RMI electricity consumption by 2025, 6 GWh by 2030, and 20 GWh by 2050, largely on the Majuro grid. This was based on assuming a phased replacement of all gasoline powered passenger vehicles and gasoline powered vessels with battery powered electric vehicles and vessels. Transportation modes currently powered by diesel or jet fuel were assumed to be powered by fuels other than electricity in the future.

Aggregated charging of electric vehicles was assumed to be incentivised or controlled to closely coincide with solar energy production. The effect of this charging on peak loads, and hence battery inverter and distribution network requirements, was not addressed. It is important to note that it was assumed that EV batteries do not discharge to grid and do not form part of grid storage as is often proposed for smart grid systems.

1 Background / Introduction

The scope of the RMI Electricity Roadmap is limited to potential pathways to reduce greenhouse gas emissions in the Marshall Islands electricity sector. However pathways to emissions reductions in other sectors may include some degree of transition from fossil fuels to electric power. As part of developing pathways for the electricity sector, assumptions have been made about the future demand for electricity. This technical note documents the assumptions made about new electricity loads which result from the potential future uptake of electric transport in RMI.

2 Assumed candidates for electric transport

As documented in technical note GHG inventory and electricity sector targets, emissions from commercial fishing vessels have been excluded from the RMI Electricity Roadmap, and as a result were not considered.

It was assumed that any emissions reductions in domestic aviation would in the first instance come from efficiency improvements and a targeted flight schedule, and that further improvements leading to zero-emissions flight would require development and supply of an alternative non-electric fuel.

Mobile commercial or industrial machinery (for example excavators) often rely on internal combustion engines powering hydraulic pumps and actuators developing immense power. It was assumed that this machinery and vehicles currently powered by diesel would continue to rely on liquid fuels, for example biodiesel.

It was assumed that diesel powered vessels are required to have large ranges, and that these would continue to rely on liquid fuels.

As a result, reducing the emissions resulting from the current combustion of jet fuel or diesel for transport was assumed to be achieved from measures other than electrification.

On the other hand, transport modes currently powered by gasoline were assumed to be viable candidates for powering from electricity by the years 2025, 2030 and 2050. Manufacturers of passenger vehicles are already significantly scaling up battery powered electric vehicle (EV) production, partly in response to emissions efforts in more developed countries. In addition, research and development of hydrogen fuel cell powered passenger vehicles continues; with hydrogen an energy carrier which can be produced through the electrolysis of water using electricity from renewable sources. One advantage of storing energy as hydrogen is that the production of hydrogen can be run on a deferrable basis coincident with good solar or wind availability.

Although electric vessels are not yet as widespread as electric cars, these are also currently available including electric outboards as well as ferry vehicles, and so electric vessels were assumed to follow behind electric cars in availability and practicality.

3 Assumed uptake of electric transport

Passenger vehicles in RMI are typically second-hand and aged, and so new developments in vehicle technology would normally take a long time to become prevalent. However the imminent GHG targets (2025, 2030 and 2050) require a more rapid change in the transport sector.

Replacing gasoline powered vehicles with electric vehicles is just one of many ways to reduce transport sector emissions. Examples of other measures include

- more fuel efficient vehicles;
- public transport or ridesharing which reduce the gasoline consumed per person's trip;
- electric public buses;
- transport use behaviour change (for example high gasoline prices have - in some contexts - historically correlated with a reduction in gasoline use, demonstrating that behaviour change is possible);
- zero-emissions transport such as walking or cycling; and
- alternative liquid fuels such as CNO, biodiesel, ethanol etc.

Uptake of some of these measures may reduce transport energy demand, however on the other hand, increasing numbers of cars being registered on Majuro show a general increase in expectations of mobility and convenience.

Weighing up the potential change in transport energy demand and the rapidly increasing availability of battery powered electric vehicles, the following assumptions were made for the contribution electric transport may be able to make to reducing RMI transport emissions:

- Transportation which consumed 10% of the gasoline imported to RMI in 2016 will be replaced with battery powered electric transportation by 2025;
- Transportation which consumed 30% of the gasoline imported to RMI in 2016 will be replaced with battery powered electric transportation by 2030;
- Transportation which consumed 100% of the gasoline imported to RMI in 2016 will be replaced with battery powered electric transportation by 2050.

4 Assumed effect on annual electricity consumption

1,586 thousand US gallons of gasoline were imported into RMI in 2016[1], assumed to be largely consumed for transportation.

Much of the energy in this fuel[2] is converted to waste heat when combusted in an internal combustion engine (ICE) for transport, especially in stop-start island trips and older vehicles. It was assumed that on average 30% of the available energy in the fuel would be converted to rotational energy at the driveshaft of a passenger vehicle or propshaft of a vessel.

However higher efficiencies are expected between an electric battery charging source and the driveshaft of a passenger vehicle or propshaft of a vessel. A figure of 80% was assumed, based on an average motor efficiency of 90%, an average battery roundtrip efficiency of 90%, and a battery charger efficiency of 98%.

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[1] See technical note TN 04 – GHG Inventory

[2] 32 MJ/l lower heating value https://www.engineeringtoolbox.com/fuels-higher-calorific-values-d_169.html Accessed April 2018

Factors converting shaft power to motion such as aerodynamics, hydrodynamics, weight, ground friction, propeller efficiency, auxiliary loads were assumed to be equal between ICE and EV transport applications.

This results in a projected 2 GWh of extra electricity by 2025, 6 GWh by 2030, and 20 GWh by 2050.

It was assumed that this electricity was provided by the Majuro and Ebeye electricity networks only. As of 2018, 2,366 passenger vehicles were registered in Majuro[3] and 50 in Ebeye[4]. Hence 98% of this extra electricity was assumed to be provided on Majuro and 2% on Ebeye[5].

5 Assumed effect on load profiles and peak load

Depending on how quickly EVs can be charged in the future, and whether vehicles are charged at the same time of day as each other, the effect of EV charging on network peak loads could be very significant. For example 700 EVs simultaneously charging at a low rate of 3.3 kW would add 2.3 MW to network load. This has implications for the distribution network and also for the required battery inverter size required to allow electricity production in diesel-off mode. However at this time a detailed study of the potential effect of EVs on RMI peak loads has not been undertaken.

Another consideration is whether EV charging is typically done at a time of day which coincides with solar or wind production. In a worst case scenario, vehicle owners will charge overnight when the vehicles are not required and are parked at home. In a best case scenario, incentives (such as time of use pricing) and/or control of chargers (for example, park and charge facilities near employment with charging rates controlled by the electricity utility) will encourage or mandate EV charging coincident with hours of typical solar resource.

An optimistic approach was taken, where 2/3 of charging was assumed to be incentivised or controlled to closely follow solar geometry (i.e. highest charging consumption/lowest prices around noon), while acknowledging that this would not work for all vehicle owners and 1/3 would charge overnight regardless.

Seasonal, daily and weekday/weekend variations were ignored. The average daily load profile of aggregated EV charging was assumed to follow the shape shown in Figure 1.

[3] National Police – Traffic Division
[4] Ebeye City Manager
[5] Note that golf cart type vehicles may be a more appropriate solution for Ebeye, given the very short distances and high pedestrian numbers

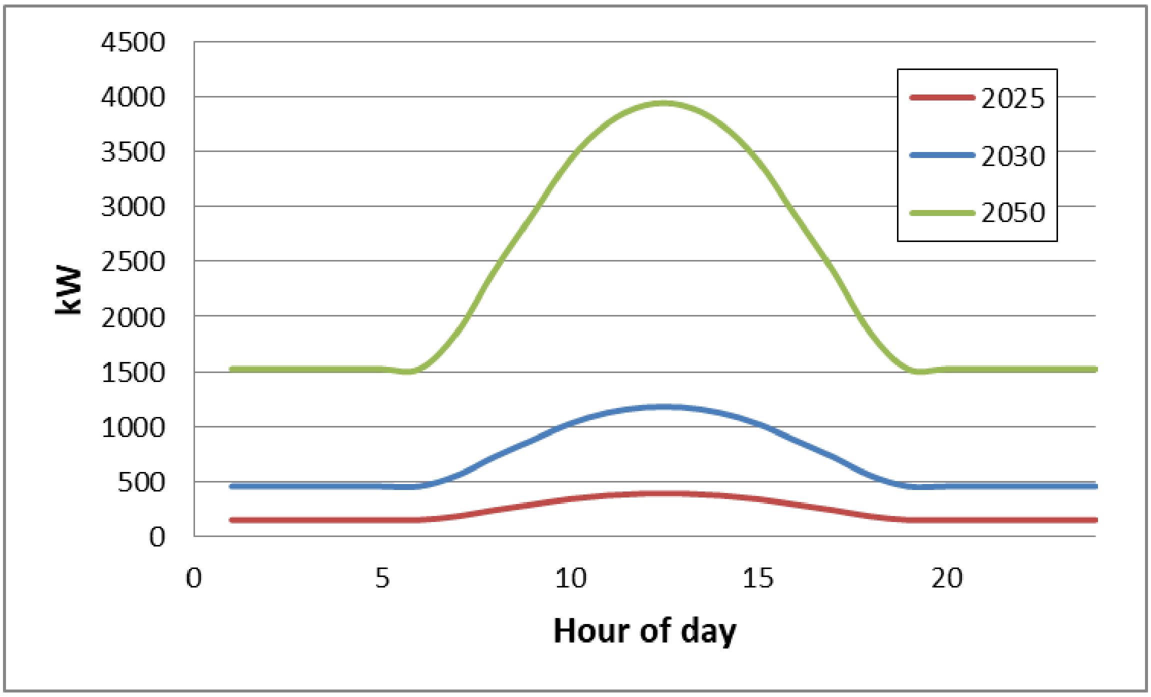

Figure 1 - Assumed average aggregated EV charging demand

It is important to note that it was assumed that EV batteries do not discharge to grid and do not form part of grid storage as smart grid technology is not considered to be practical for the RMI at this stage.

6 Conclusions

The assumption used for the RMI electricity roadmap techno-economic analysis was that an uptake of electric transport would add 2 GWh to annual RMI electricity consumption by 2025, 6 GWh by 2030, and 20 GWh by 2050. 98% of this extra electricity was would be supplied by the Majuro grid and 2% by the Ebeye grid.

This would consist of a gradual replacement of gasoline powered passenger vehicles and small gasoline powered vessel with battery powered electric vehicles and vessels. Transportation modes currently powered by diesel or jet fuel were assumed to be powered by fuels other than electricity in the future.

The uncertainty in this estimate is chiefly in the assumption that the number of vehicles would remain the same. In road transport, Majuro suffers from severe congestion from too many vehicles on the road. A better approach would be to reduce the number of vehicles through buses. In the load forecast we are however sizing the generation to accommodate electric passenger vehicles without the introduction of better public transport or changes in behaviour.

Aggregated charging of electric vehicles was assumed to be incentivised or controlled to closely coincide with solar energy production. The effect of this charging on peak loads, and hence battery inverter and distribution network requirements, was not addressed in detail.