Sector: Energy
Sub-Sector/Technology Option: Electric Vehicles
Technology Application: Introduction of Electric Vehicles.

Introduction

Globally, the penetration of renewable energy at the end-use in the transport sector is minimal. According to IRENA (2013), in 2010 only a total of 2.5% of the transport sector could be attributed to the use of renewable energy while 3.3% is attributed specifically to transport use by road. However, with advances in renewable solutions, and in particular, mass production of electric vehicles, along with supporting policies, it is expected that by 2020 renewable energy penetration in the sector would be significant.

Guyana has a high dependence on imported petroleum-based products as its main source of energy. In 2012, 4.9 million barrels of petroleum-based products were imported, 13.42% more than 2011, and at a cost of US$599,946,823, equating to approximately 24% of Guyana's gross domestic product (GEA, 2014). Guyana's transportation sector in recent years has grown as the country's largest user of total petroleum-based products, consuming approximately 38% in 2012, and superseding the electricity generating sector (33% in 2012) (GEA, 2014). In 2014, the transportation sector consumed 35% of total petroleum-based products. The greenhouse gas inventory prepared as a component of Guyana's SNC concluded that total emissions of carbon dioxide from the energy sector[63] from fuel combustion is 2,093Gg for 2001 or 56.9% and 1,657Gg for 2004 or 44.7%. Emissions of carbon dioxide from the consumption of fuel in the transport sub-sector, consisting mainly of road transport, inland transport via waterways to a lesser extent and inland aviation, ranged from 210 Gg (14.6% - 1990 – 1994) to 335 Gg (19.8% - 2000).It is highly probable that emissions of carbon dioxide have increased in recent years due to the increased consumption of petroleum-based products in the transport sector.

While considerable efforts are being made to use biofuels in vehicles in Guyana, its diffusion and commercialization into the wider local market remains limited. One approach to directly lower the carbon dioxide emissions and energy consumption is through the use of high energy efficient vehicles such as electric vehicles in the light-vehicle[64] sector.

The use of electricity as an energy source for vehicles from renewable sources is one way to reduce fossil fuel use in the transport sector. There are two (2) main categories with a number of options to electrify vehicles. The first category is vehicles operating purely on electricity or 100% electric propulsion for mobility. These are called electric vehicles (EVs) or battery electric vehicles (BEV) and can source electricity either from the grid or off-grid. This type of vehicle uses a rechargeable battery-pack to power an electric motor (s) for mobility and auxiliary power without the use of the internal combustion engine, fuel cell or tank. The second category is the use of hybrid electric vehicles, in series or parallel configuration, and there are a number of options for these kinds of vehicles ranging from mild hybrid, full hybrid, and plug-in hybrid to extended range hybrid. The batteries on these vehicles are smaller in comparison to the EVs, can be plugged into the grid to charge, using a downsized internal

[63] The GHG inventory prepared for the SNC stated that the energy sector comprises the following six (6) subsectors - energy industries, manufacturing & construction, transport, commercial/institutional, residential and agriculture, forestry fishing.

[64] These are cars, SUVs and light trucks.

combustion engine to provide power when the battery is at minimum discharge level or under specific driving conditions, as needed. This factsheet focuses on the application of the electric vehicles to the vehicle fleet in Guyana	
Technology Characteristics	
Features	The critical components of an EV are the electric battery and charger, electric motor and motor controller. The battery can be charged by direct connection to the grid or by 'regenerative[65]' braking. Power is supplied to the electric motor via the motor controller and is then converted for use (Helmers *et.al,* 2012*)*. Lithium-ion (Li-Ion) battery chemistry is the technology of choice for EVs because of their specific energy and power density qualities. These are necessary performance requirements to allow for the mainstreaming EVs.
Capital Investment Cost	Conventionally, EVs were about 2-3 times more expensive than the internal combustion engine vehicles (ICEV) mainly due to high cost of the battery-pack. This cost is the capital investment that that could be recouped over time by the low running cost (Simpson, 2011) and enhanced performance of the batteries. On average, annual cost of ownership varies significantly based on the type of vehicle and market/region of deployment (IRENA, 2013). A 2016 Nissan Leaf[66]can be sourced at the manufacturer's suggested retail price (MSRP) starting at approximately US$30,000 to US$37,000[67] depending on model, range (84 or 107mile range) and capacity of the lithium-ion battery (24kWh or 30kWh).
Operating Cost	EVs have low operating costs in terms of energy use and maintenance. IRENA (2013) and Simpson (2011) stated that battery costs dominate the costs of EVs. IRENA (2013) projected that EVs are in the early stages of mass commercialization and this has a bearing on cost reduction over time. It is projected that cost reductions will be significant by 2020, that is, the overall cost of EVs, including that of the battery will become competitive with ICEVs markets providing that supporting policies are in place. Future battery packs costs are projected to be between US$ 300 and US$ 400/kWh for EVs by 2020. It is also projected that improvements in battery technology will allow for enhanced battery performance thereby extending the overall battery life (IRENA, 2013).
Maturity	The technology platform for EVs has been in use for over a century and is available in many different forms across the spectrum. Significant advancements were made in recent years, especially to the battery performance and life of the EVs to make them comparable in terms of cost and performance to the ICEVs. Current development places EVs at the early stage of mass commercialization and close to being competitive with the intention to fully diffuse the technology across various markets and regions by 2020, providing that the supporting policies are in place.
Country Specific Applicability	

[65] Regenerative braking allows for the capturing the energy created by the momentum of the vehicle at the moment of braking to re-charge the battery, which would otherwise dissipate as heat, Simpson (2011).
[66] IRENA suggests a cost ranging from 35200 – 37250 at a range of 117 km (using 2013 figures).
[67]http://www.nissanusa.com/electric-cars/leaf/.

Status of technology in country	EVs are new to Guyana. Currently there is no known application of EVs to the vehicle fleet in country and any introduction would require supporting polices for its transition and operation, in particular, to support the recharging infrastructure.
Market potential	EVs are at the early stage of mass commercialization to allow for rapid uptake by 2020 and beyond. It is forecasted that EVs could account for at least 5-10% of new vehicles sold by 2020 (Simpson, 2011) as a result of a number of factors including increases in performance and reduction in costs making EVs highly competitive with ICEVs.
Scale of application and time horizon	The Guyana Energy Agency (GEA) plans to introduce a Nisan Leaf to its fleet of vehicles for testing in the short – medium term. Thereafter, in the medium to longer-term and based on acceptability, cost and recharge infrastructure, EVs could be added to the in-country fleet over the next10-15 years.
Institutional and Organisational requirements	The legal and regulatory requirement for EVs is embodied in the Guyana's Energy Policy and the GEA legislative framework. Regulations and standards will be required to ensure vehicle safety and fleet monitoring, as well as, deployment. Incentives should be considered to encourage diffusion in the long term.
Operation and maintenance	Special technical trainings are required to ensure that acceptable and appropriately safe maintenance and repair can be conducted. EVs will require battery changes over the life of the vehicle since the battery performance degrades over time with the number of charge cycles (charge/discharge cycles).
Scale/size of beneficiary group	The beneficiary groups could vary based on the adoption of the technology. In the first phase, EVs will be limited to GEA with the intention to diffuse across government agencies in the medium to longer term.
Acceptability to local stakeholders	This technology may take some time to be accepted by the wider stakeholder groups in Guyana providing the barriers, especially cost and understanding of the recharging infrastructure, can be addressed.
Endorsement by experts	EVs are endorsed by the GEA. The GEA is currently exploring sourcing a Nissan Leaf for testing in Guyana's context.
Barriers and Disadvantages	▪ Battery charging using non-renewable sources or fossil fuels can be considered counterintuitive in terms of GHGs reduction. ▪ The cost of EVs, in particular, high costs associated with the battery-pack, recharging infrastructure, range and size/capacity of batteries need to be addressed to allow for mass-market uptake. ▪ EVs are more appropriate for urban transport use due to the limited driving range as a result of small battery-pack. Smaller battery-packs are installed as one way to reduce the overall purchase costs of the vehicle. ▪ The associated cost of charging units need to be factored into the overall operating costs. Additionally, there is no standardized system to charge EVs – whether this is related to circuit rating and power of charging system or power and current delivery (AC/DC). ▪ Mass production, although commenced, is still limited to selected manufacturers and regions.

	▪ Battery life for the lithium-ion batteries significantly reduces when operating at high temperatures. To address this, the Nissan Leaf & Mitsubishi "I" use a cheaper "forced air system". ▪ The battery charger is a crucial component of the EV system. The charger efficiency can vary between 60% and 97% - wasting 3% -40% of the grid energy as heat.
Mitigation Benefits	
Greenhouse gases abatement potential	The electrification of the light-vehicle fleet in the transport sector using EVs has significant mitigation potential. EVs operate at high energy efficiency, about 2.5 -4 times more than conventional engines, and produce zero 'exhaust' emissions thus offering a carbon-neutral solution as long as the batteries are recharged from renewable sources.
Potential Development Benefits: Economic, Social, Environmental	
Economic benefits	▪ The introduction of EVs will improve energy security and reduce dependence on imported petroleum-based products. ▪ EVs, based on projections by IRENA (2013), can be cost competitive with internal combustion engines and by 2020 due to mass production and diffusion are readily available, with low running costs in terms of energy use and maintenance. ▪ EVs can be recharged with electricity produced from local sources. ▪ EVs can be supported through augmentation of existing electrical energy infrastructure in the short term. It is important to ensure that the electrical energy is from renewable sources.
Social benefits	▪ Electric motors are cheaper and more efficient than internal combustion engines and reduce local pollutant emissions, providing indirect health benefits. ▪ EVs are economical to operate, thus, allowing for cost savings from the use of less energy and maintenance. It means more money is available for other purposes.
Environmental benefits	▪ As a result of producing zero tailpipe exhaust emissions such as soot or NOx, EVs contribute to improvements in local air quality, especially in urban areas. ▪ EVs are characteristically more silent than conventional vehicles with internal combustion engines and therefore reduce the overall noise levels in urban areas.

References:

1. Fiischedick, M., R. Schaeffer, A. Adedoyin, M. Akai, T. Bruckner, L. Clarke, V. Krey, I. Savolainen, S.Teske, D. Ürge-Vorsatz, R. Wright, 2011: *Mitigation Potential and Costs*. In IPCC *Special Report on Renewable Energy Sources and Climate Change Mitigation* [O. Edenhofer, R. Pichs-Madruga, Y. Sokona, K. Seyboth, P. Matschoss, S. Kadner, T. Zwickel, P. Eickemeier, G. Hansen, S.Schlömer,C. von Stechow (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA
2. Guyana Energy Agency (GEA), (2014): Strategic Plan (2014 – 2018) *(Draft)*
3. Helmers, E., Marx, P., (2012): Electric Cars: Technical characteristics and environmental impacts. Published in Environmental Science Europe.

4. International Renewable Energy Agency (IRENA) (2013): Road Transport: The Cost of Renewable Solutions – Preliminary Findings. www.irena.org/publications
5. Kaieteur News (2016): Energy efficient stoves among projects for 2016. Published in Kaieteur News, Sunday January 03, 2016.
6. Simpson, A. (2011): Electric Vehicles. In Technologies for Climate Change Mitigation: Transport Sector. [Dhar, S., Newman, P., & Salter, R.(Eds.) and Reviewed by Hidalgo, D., Litman, T., & Rogat, J.]
7. http://www.climatetechwiki.org/technology/electric-vehicles
8. http://www.nissanusa.com/electric-cars/leaf/ (accessed December 04, 2015).