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A3 – Two and three-wheelers and quadric cycles

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Summary

The transportation sector contributes for a significant proportion of local and global urban *pollution* and Greenhouse gas (GHG) *emissions* in Sri Lanka and its contribution is likely to grow in the coming years. The *tricycle* continue to occupy a 24% share of the 4 million active vehicle fleet of Sri Lanka and are contributing 15% of passenger km from the passenger transport vehicles. Conversion of *ICE (internal combustion engine) tricycle* to *Electric drive* is the sustainable *energy* solution for the existing inter-modal transport system using *gasoline engine*.

1. Introduction

E-Stroke is the conversion of ICE (internal combustion engine) tricycle to Electric drive; sustainable energy solution for the existing inter-modal transport system using gasoline. Tricycle taxis are selected as the target for implementation of this project to reduce urban air pollution, due to the large share of transport demand served by them; the focus of this project is on ICE tricycles. Tricycles are commercial vehicles with reasonably heavy and predictable usage pattern in Sri Lanka they provide a vital inter-modal transport solution to city dwellers, especially during off-peak periods. Population of the tricycles in Sri Lanka is 929,495 up to 2014; they are primary wage earners for tens of thousands of owners/drivers of the poorer segments of society. It is relatively easy to calculate and judge Return on investment on vehicles with this new technology.

1.1. Current Situation

Tricycle taxis are selected as the target for implementation of strategies to reduce urban air pollution, due to the large share of transport demand served by them; the focus of this project is on ICE tricycles. Following images shows current situation on streets.



Figure 1: Tricycle taxis on streets

1.2. Benefits of E-STROKE Electric Conversion

1.2.1. Saving Energy and Fuel

It is assumed that 5 Litres of gasoline or 5.8 kWh is necessary to operate 100 km of the three-wheeler under general conditions. In energy, less energy is consumed in electric three-wheelers to operate the same distance.

1.2.2. Saving in pollution related Health Costs

Exposed to the vehicular emissions in significant concentrations, these pollutants are known to cause severe damage to the health of the people, by way of premature mortality and morbidity, and thus threaten economic growth.

1.2.3. Saving in noise related Health Costs

Additional health and social benefits are likely to accrue out of the reduction of noise pollution by virtue of the fact that electric vehicles are almost whisper quiet whilst 2-stroke engines are known to be very noisy. Studies conducted on operating electric 3 wheeler and ICE units show a potential noise reduction of 99%.

1.2.4. Creation of additional jobs

It has been estimated that every conventional 3 wheeler generates revenue to support an equivalent of 2 families – one being that of the owner/ driver and the other that of the maintenance personnel. Electric 3 wheelers maintenance would require more sophisticated education and training. Specifically, maintenance of advanced

electrical and electronic subsystems, and, large scale battery charging and maintenance would open fresh paths for the educated, unemployed youth by creating more than 2000 new jobs.

2. Conversion Process

The conversion process has currently been tested on 3-wheelers of five clients, which were provided by Sri Lanka Three-Wheeler's Association and the three-wheeler provided by company of Gas Auto Lankan (Pvt) Ltd. By the work force of the project intend to allocate for the workshops, conversion can be done within one day.

Step 01 – Remove tricycle body

Step 02 – Remove all the engine, wire harness and related parts

Step 03 – Install Electric motor, Controlling unit, Wire harness and related accessories

Step 04 – Install battery pack

Step 05 – Re-install tricycle body and Complete

3. Project Activities

3.1. Data collection, survey and performance monitoring of E-STROKE.

LAUGFS already started the data collection activities developed under the E-STROKE program to track the performance of the vehicles in the field and survey their operation. This is accomplished by providing the participating of prototype tricycle owners with GPS trackers and log sheets that are documented on a daily basis, and compiled by LAUGFS monthly into a single database.

3.1.1. Select project location - Colombo

Colombo city tricycle taxis are the selected as the target for implementation of E-STROKE project and strategies to reduce urban air pollution and noise, due to the large share of transport demand served by them in Colombo city. Nearly 50% of the ICE tricycle population running as taxis in Colombo city.

3.1.2. Data Collection

On board measurement method (considering the traffic behavior) has been used for the data collection and performance monitoring. Number of data samples for each route calculated proportionate to the traffic volume.

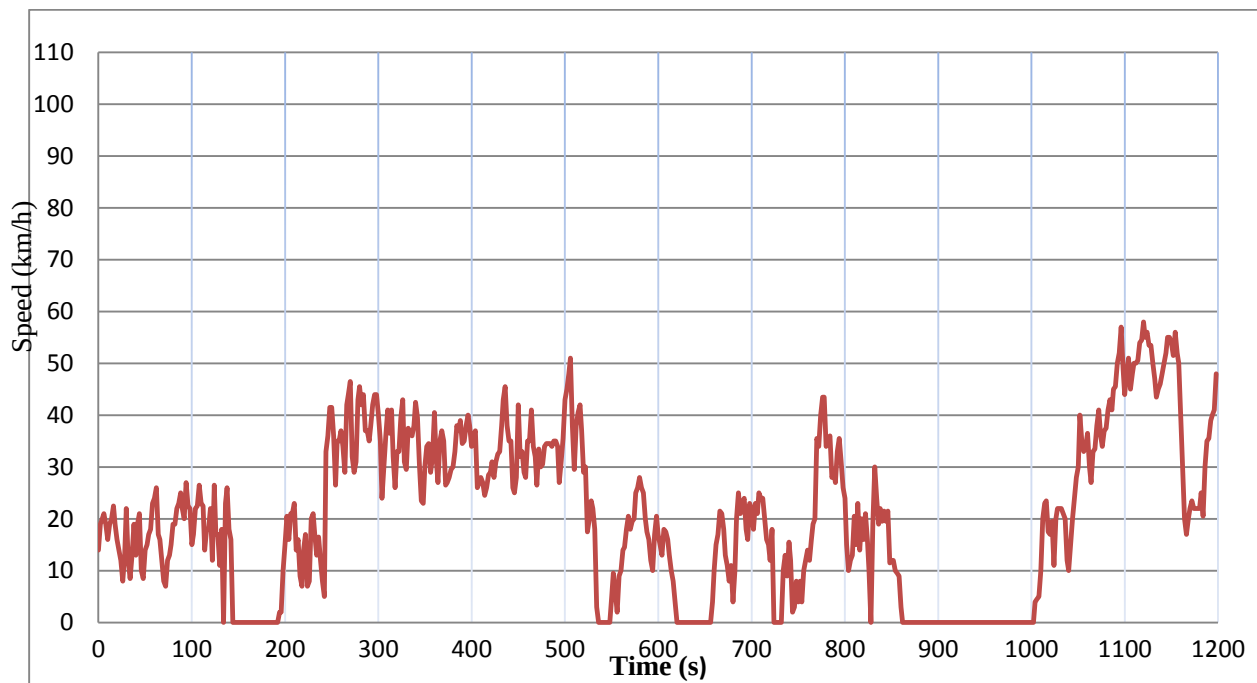
Samples were further divided in to time period of the day using hourly traffic volumes.

Off peak	- 8.00 PM (Previous day) to 6.30 AM
Morning peak	- 6.30 AM to 10.00 AM
Inter peak 1	- 10.00 AM to 12.00 AM
School peak	- 12.00 AM to 3.00 PM

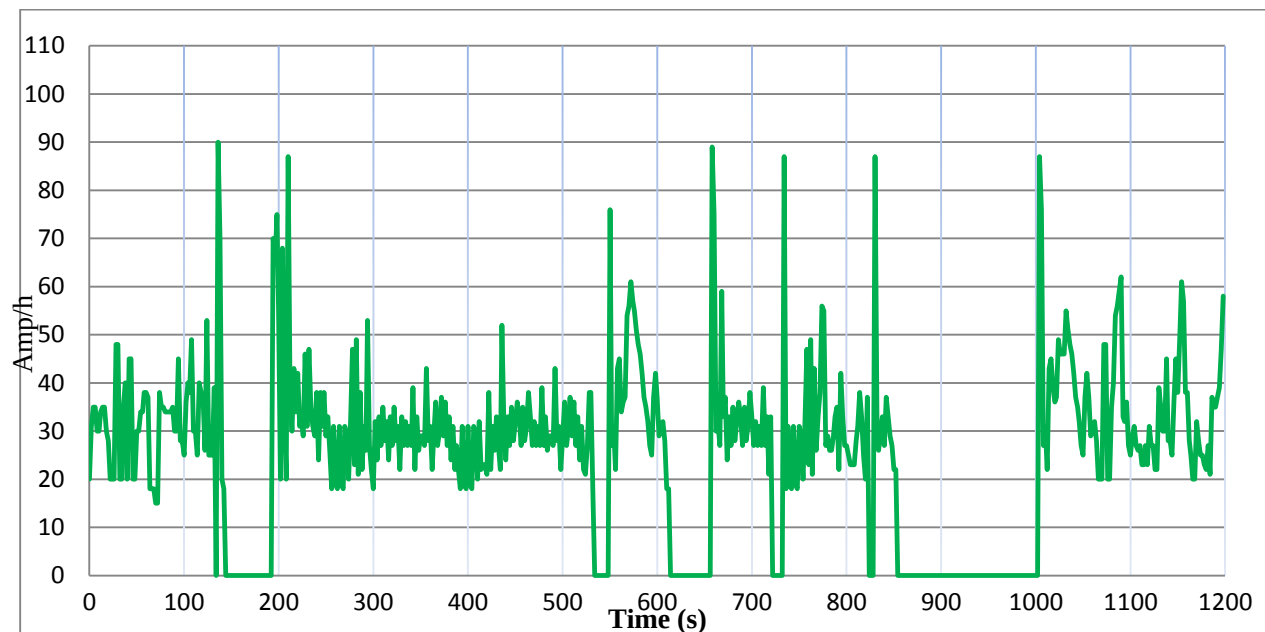
Inter peak 2	- 3.00 PM to 4.30 PM
Evening peak	- 4.30 PM to 8.00 PM
Evening off peak	- 8.00 PM to 6.30 AM (Next day)

3.1.3. Performance Monitoring (Testing)

Model Driving Cycle (Average driving pattern of a tricycle driver in Colombo)



Power Usage of the motor for the Model Driving Cycle (Average Amp/h usage of the motor)



3.1.4. Train customers, drivers, and maintenance support personnel

LAUGFS, with the support from its component suppliers, has developed the necessary training documentation, procedures and driving patterns. This will include owner, service, and parts replacement manuals. This will help to save life time of the battery by training best driving pattern for the drivers/owners.

3.1.5. Enhance charging station infrastructure

As a standard charging source of the Electric tricycle, on-board charger will be provided to plug into any standard 220V, 50 Hz wall outlet as a home charger. Furthermore Laugfs plan to establish island wide charging stations by using existing company infrastructures 181 locations can be used to establish charging stations for the Electric 3-Wheelers.

To be more sustainable of the E-Stroke project the power source for all the charging points will be solar powered, which would mitigate any adverse impact of increasing demand of electricity requirement in Sri Lanka.

4. Batteries used for Prototype

Laugfs used Sealed Lead Acid batteries for the prototype; which comes with sealed in a hard plastic case and can be turned in any orientation safely without leaking acid.

The biggest advantage of lead acid batteries is their price. Disadvantages of lead acid batteries are the low charging cycle's and weight. Due to low charging cycles of the batteries and driving patterns of the driver's, capabilities of the lead acid batteries are limited. Lead acid batteries only has capacity to run 100Km per charge in new batteries, when the batteries are getting weaken number of kilometers that can run per charge are falling down continually. To achieve this obstruction, Laugfs is planning to have Lithium-Ion batteries for the E-STROKE future conversions.

5. Safety

Lead acid batteries are much larger and heavier than lithium batteries, limiting their placement on tricycle. They almost never come packaged with tricycle specific mounting hardware which means that they generally have to mount on the rear engine compartment. Mounting them up high on the rack isn't a good idea either because it will negatively affect handling. Need to mount the batteries as low as possible to keep the center of gravity of the tricycle lower in the engine compartment. This is significantly improving the handling of the tricycle. Lead acid batteries that used are comes with sealed in a hard plastic case and can be turned in any orientation safely without leaking acid. On the occasion of accidents there is a special feature automatically cut off the power supply of the motor.

6. Research & Development

R&D team doing research continually to improve technical components of the conversion kit, improving the following components will be increase drive range & also expecting to reduce the price of the conversion.

Battery - Changing lead acid batteries to lithium ion.

Motor & Motor Controller – Regenerative Braking / Transmission

Capacitors – Start & Stop

7. Tables and Equations

7.1. Tables

Table1: Battery Specification

	Voltage	Amperage	Qty	Size	Weight
Sealed Lead Acid Battery	60V	100A	5	H: 213 mm/ L: 331 mm/ W: 173 mm	160 Kg

Table2: Performance Specification

Table2: Energy saving

	Gasoline	Electricity
Fuel consumption per 100 km	5 L	5.8 kWh
Energy consumption (MJ/100 km)	169	20.8

Table3: Conversion cost recovery

	Conventional 3-Wheeler	Electric 3-Wheeler
Initial Cost	-	USD 2074.07
Cost per km	USD 0.046	USD 0.012
No of Units per Charge	-	4.5 kwh
No of km per Day	100km	100km
Cost Recovery	-	1 Years and 9 Months

ITEM		Test Conditions	ICEV (Existing)	EV (Expected)
Table4: Benefits of conversion				
1	Shell Weight (kg)		350	440
2	Payload (kg)		334	334
3	Top Speed (km/h)	Max GVW	55	40
4	Gradeability (%) @ 10 km/h 20 km/h 30 km/h 40 km/h 50 km/h	Payload= 334kg	16 — — — —	12 12 12 12 -
5	Acceleration (sec) 0 to 20 km/h 0 to 30 km/h 0 to 40 km/h 0 to 50 km/h	Payload = 334kg	6 11 16 21	5 10 15 -
6	Range (km)	Payload = 150kg	100 km per 5 Litres	100 km per 5kWh
7	Fuel Economy		5 Litres	100A
8	Battery Voltage	60 V Max		

	Conventional 3-Wheeler	Electric 3-Wheeler
Initial Cost	-	USD 2074.07

Cost per km	USD 0.046	USD 0.012
No of Units per Charge	-	4.5 kwh
No of km per Day (Approx)	100km	100km
No of working days per month (Approx)	26	26
Fuel/ Electricity Cost Per Year	USD 1674.6	USD 400
Maintaince cost per year	USD 114.45	USD 11.12
No of Years caculated	10	10
Total Engine, Battery and Controllars Repair / Replace for 10years (Approx)	USD 1111.12	USD 4888.89
Total Expences for 10 Years	USD 19,002.67	USD 9000
Total saving		USD 10,002.67

7.2. Equations

(1) Watts to Mega joules

$$E_{(J)} = P_{(W)} \times t_{(s)} \quad (1)$$

(2) Tractive force

$$\frac{T(e)P(t)G}{R(r)} \quad (2)$$

References

- (1) *IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)* e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 11, Issue 2 Ver. VII (Mar- Apr. 2014), PP 35-41 www.iosrjournals.org

Authors



Chinthana Wegapitiya, was graduated from University of Bangalore in 2003 with Bachelor of Business Management with 1st class .and training in Italy, Poland and India in Automobile technology.

In 2014 he and his team develop the concept on converting Petrol three wheeler in to Electric with milestone achievements.