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## Micro-hybrid with Ultra-Capacitor Based Three-Wheeler

**Sabhasachi Saha<sup>a</sup>, Souvik Roy<sup>b,\*</sup>, Md. Sazid Rahman<sup>c</sup>, Md. Zahid Hasan<sup>d</sup>**

Department of Industrial & Production Engineering,  
Rajshahi University of Engineering & Technology, Rajshahi, Bangladesh

<sup>a-d</sup>E-mail address: [sabha.showmo@gmail.com](mailto:sabha.showmo@gmail.com) , [souvikroyksd@gmail.com](mailto:souvikroyksd@gmail.com) ,  
[sazidrahmanipe@gmail.com](mailto:sazidrahmanipe@gmail.com) , [zahidipe13@gmail.com](mailto:zahidipe13@gmail.com)

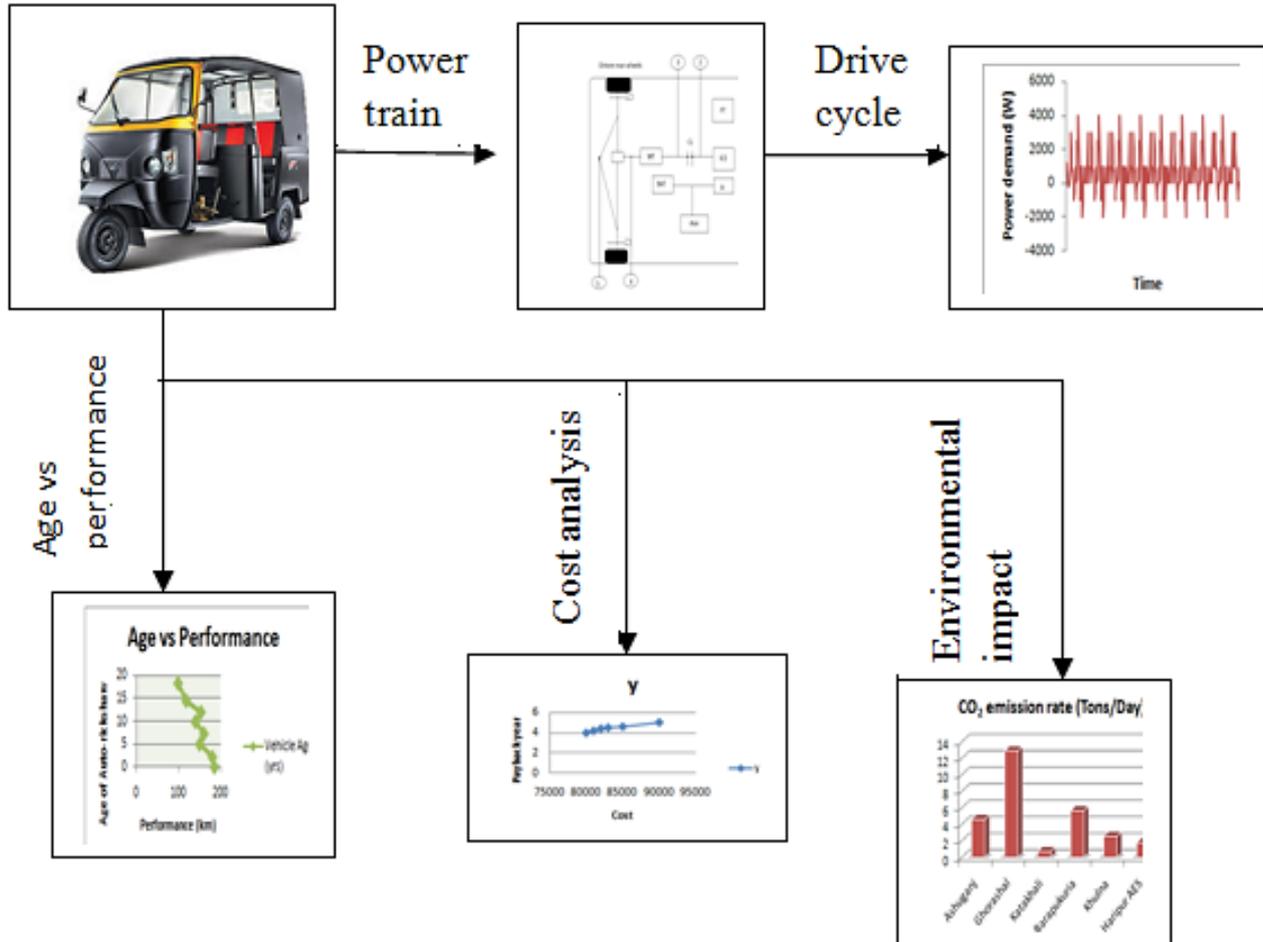
\*Corresponding author: [souvikroyksd@gmail.com](mailto:souvikroyksd@gmail.com)

### ABSTRACT

Execution of customized Start/stop (SS) advancement in a medium vehicle is a fiscally canny way to deal with improves mileage and rot surges without influencing purchaser request. In urban degrees, where an unbelievable bit of the vehicle driving time is spent sitting at stop lights, the motor can be closed down so spare fuel. The motor is quickly and carefully restarted as the driver quickens it. This working strategy is a significant part of the time utilized as a bit of full small-scale half breed electric vehicles that have fantastic power sparing potential. In this paper the framework is introduced in a Three-Wheeler where the regenerative braking and Stop-Start strategy of the Micro Hybrid structure is worked by Ultra-capacitor alongside Traditional battery. The power conveyance and investigation of vehicle is appeared in paper which was finished by MATLAB. An attainability investigation for Bangladesh is likewise led in this paper.

**Keywords:** Micro-hybrid, Ultra-capacitor, Three-Wheeler, Fuel Economy, Environment Friendly Vehicle

**GRAPHICAL ABSTRACT**



**1. INTRODUCTION**

Bangladesh's streets are getting to be plainly congested with not just transports and autos, especially, with three-wheeler and bikes. Bangladesh is a home of gigantic measure of auto-rickshaw and consistently more than fifty thousand three-wheelers are sold every year, and the number is developing. Here, industrialization is expanding more quickly than urbanization and the expanding movement intensifies effectively common contamination issue [1, 2].

In Bangladesh the greater part of the three-wheeler is sent out from India and china. With the variables of contamination, cost and expanded movement as a main priority, the most ideal approach to patch up the rickshaw is to build up a more productive cross breed plan. This paper portrays an innovative three-wheeler vehicle by utilizing a ultra-capacitor with it and its plausibility examination is finished.

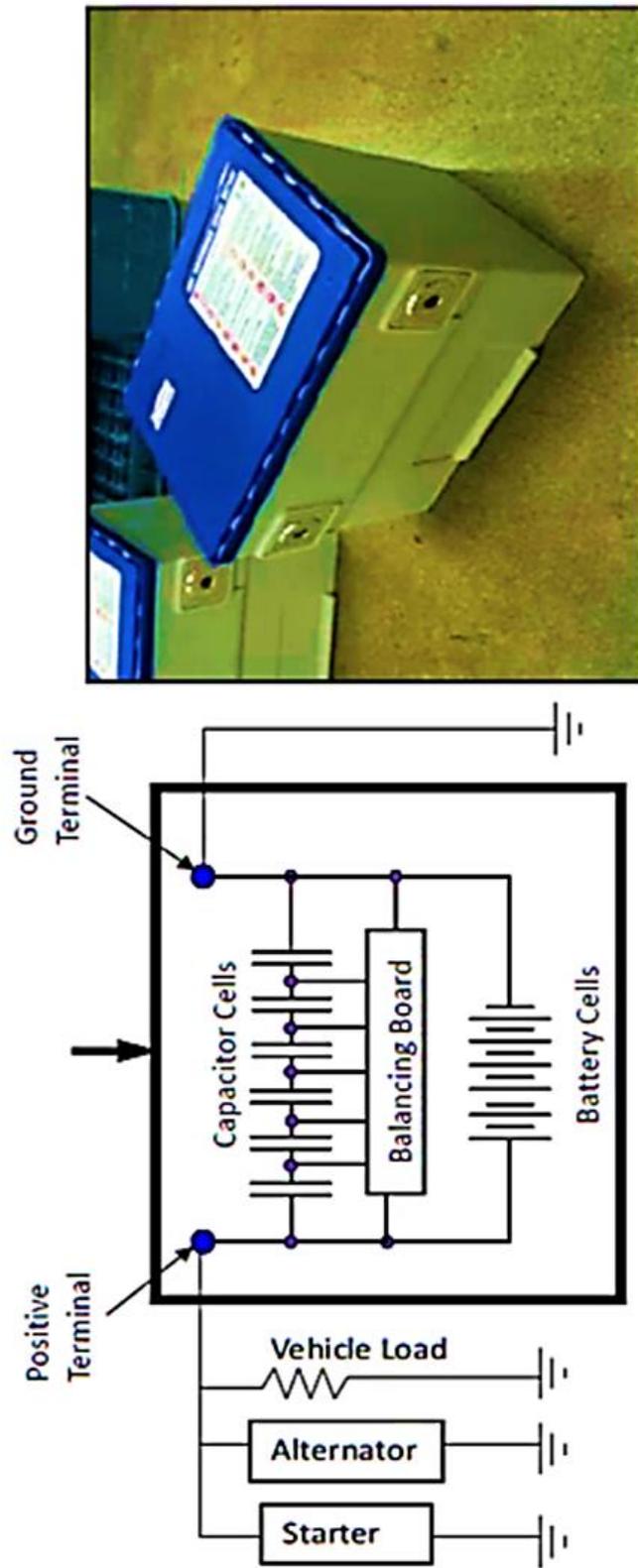


Figure 1. Ultra-capacitor/battery hybrid. (Maxwell Technologies

There are a few cross-breed structures have been realized on three-wheeler. A Micro-Hybrid system is best for Bangladesh diverging from other hybrid structures considering cost, comfort and ecological contamination. A Micro Hybrid vehicle what's known as a "Start/Stop Structure" where a regenerative braking device stops the devouring engine when the vehicle pulls a stop and again restarts it when the driver accelerate.

This is the minimum troublesome sort of Hybrid structure where a battery is used for the Start-Stop and regenerative braking system. T. Hofman et al. [3] first executed littler scale hybrid system in three-wheeler. V.N. Supe et al. associated this instrument in car and got 5% extra mileage [4]. In this paper an Ultra-capacitor is hybridizes with a Battery. Ultra-capacitors can store and release essentialness with high electric power quickly and feasibly conversely with batteries, which are better fitting for store a great deal of energy, however should be charged and discharged at low electric power levels to avoid bothersome maturing.

At present, producers are picking Ultra-capacitors to control start stop applications, particularly when quick restarts are required, and for keeping up the vehicles supply voltage. The voltage can be decreased all around in light of the way that standard restarts tend to deplete the battery. With their intense energy thickness, Ultra-capacitors can guarantee essentialness is passed on rapidly, considering autos to restart in a split second instantly in vehicle operation. Fig. 1 exhibits an Ultra-capacitor which is used as a piece of Micro-Hybrid framework. Table 1 shows the differences between battery, Ultra-capacitor and electrostatic capacitor.

**Table 1.** Characteristics of Ultra-capacitor, electrostatic capacitor and battery [3]

Device name	Discharge time (s)	Charge time (s)	Specific energy (KW/kg)	Specific power (W/kg)	Efficiency (%)	Serve life
Ultra-capacitor	1-30	1-30	1-10	1000-2000	0.9-0.95	>10000
Electrostatic capacitor	$10^{-6}$ - $10^{-3}$	$10^{-6}$ - $10^{-3}$	<.01	>10000	1.0	unlimited
Battery	(0.3-3) hrs	(1-5) hrs	20-100	50-200	0.7-.085	500-2000

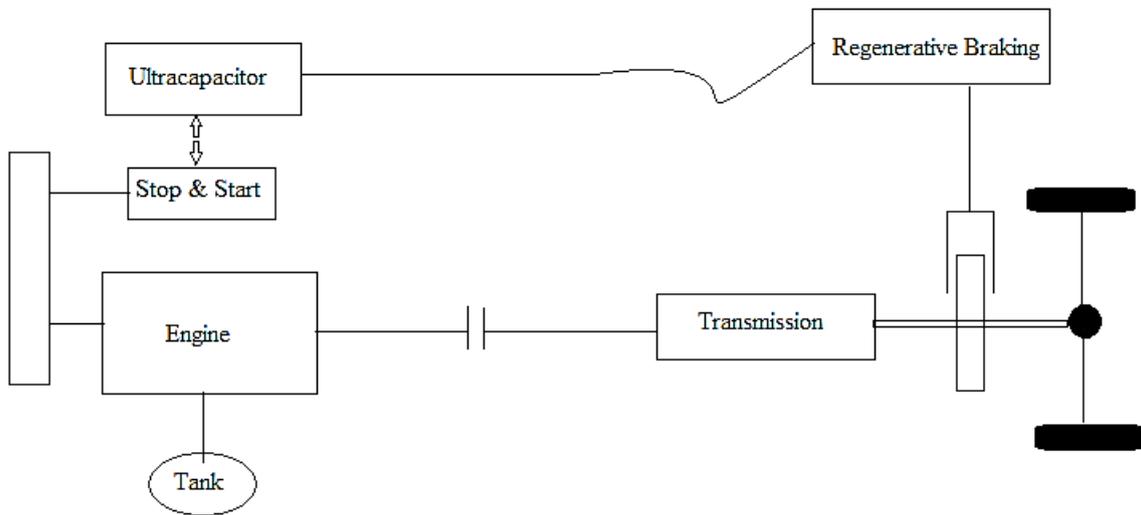
## 2. EXPERIMENTAL / RESULT

### 2. 1. Power train of Micro-Hybrid with Ultra-capacitor based Three-Wheeled vehicle

Ultra-capacitors essentially upgrade control association in half and half vehicles. Notwithstanding that Ultra-capacitors lessen surges, improve fuel-capacity and electrical

drive limits. Using Ultra-capacitors licenses the HEV to recoup and reuse braking vitality. Risen up out of run of the mill diesel motors the diminishing of fuel usage is overviewed to be higher than half. Decline in particulate releases is 90% or amazingly more and also, the diminishment of nitrogen oxide. The frameworks isolate by the power necessity for the vitality putting away structure.

The battery can be down-sized and its lifetime unequivocally be extended, thusly lessening cost. The Ultra-capacitors association ensures higher lifetime of the battery, as it draws in the battery to manage the vitality necessities while the capacitors handle the extreme requirements [5, 6]. Fig. 2 demonstrates a Micro-Hybrid structure plot. In the framework Ultra-capacitor bears most of the charge and decrease changes consequently builds the battery lifetime [7, 8].



**Figure 2.** Proposed Vehicle power train (Ultra-capacitor + start/stop + regenerative braking)

## 2. 2. Simulations and Results

The simulation was done using MATLAB Simulink program. Hybridization of battery and Ultra-capacitor helps to discharge the battery with lower fluctuations. Fig. 3 and Fig. 4 respectively represents the simulated results. Fig. 5 is the urban drive cycle applicable for Bangladesh

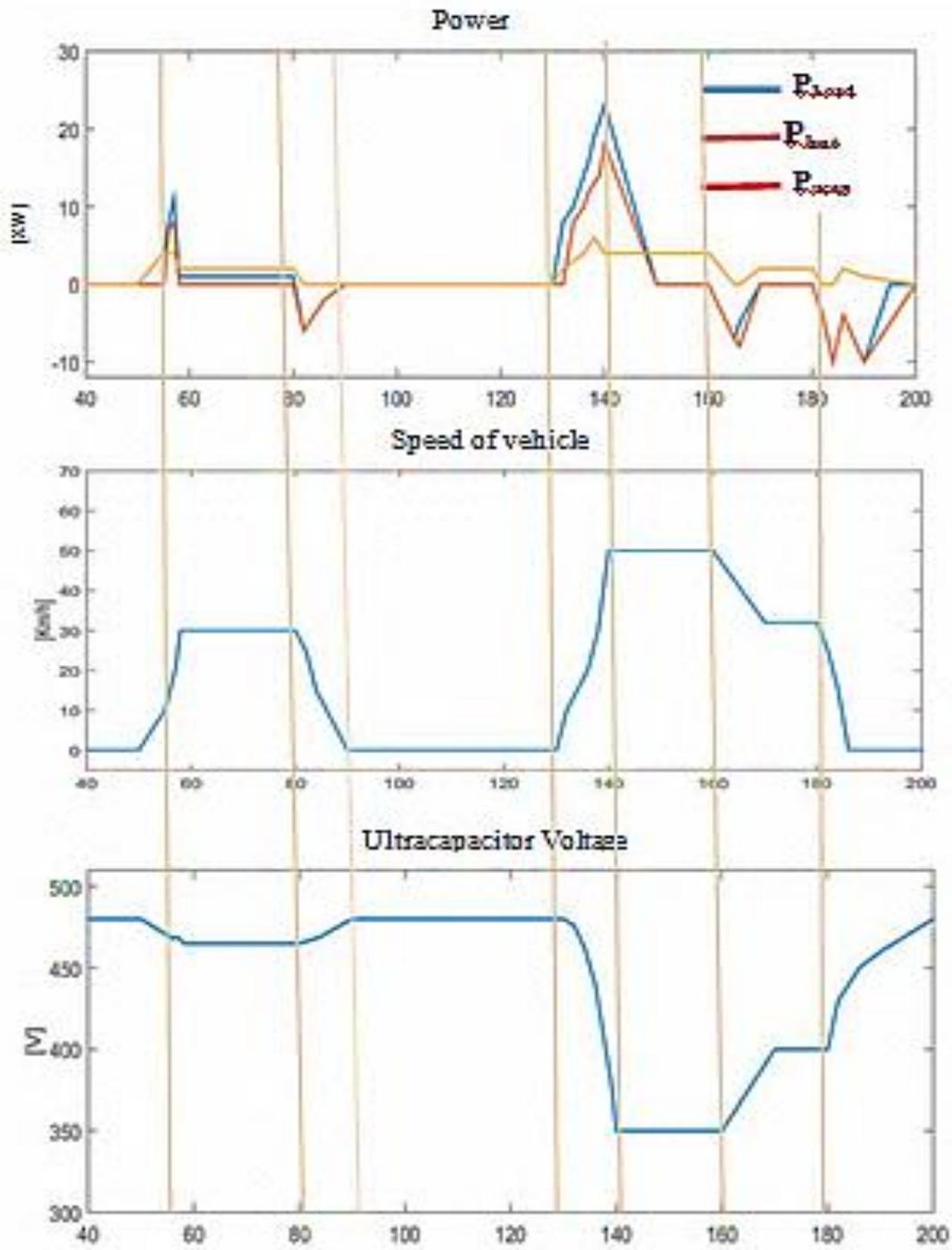
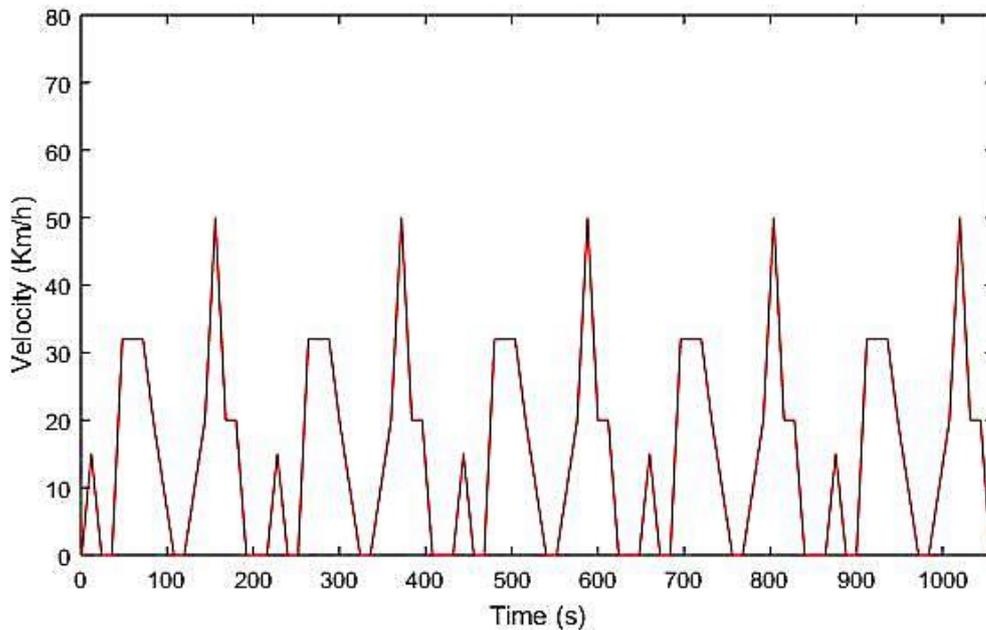


Figure 3. Power distribution in HES.



**Figure 4.** Battery power and super capacitor power of the vehicle.  
(top- super capacitor, bottom- battery)



**Figure 5.** Drive cycle of the vehicle.

### 2. 3. Cost analysis for using Ultra-capacitor with battery in Micro-hybrid system

12V, Starter Battery price (typically used in Micro hybrid system) = 65USD (Approximately). A typical Micro Hybrid in a three wheeler requires 3 to 4 time replacement in total lifetime of a three-wheeler. Taking total life time of a three-wheeler approximately 16-20 years [11-13]. If an Ultra-capacitor is installed in the system then battery life extends more than double [7] Cost of installment of an Ultra-capacitor is approximately 140 USD. So, in a typical vehicle in a whole lifetime 3 times battery replacement cost = 195 USD. If an Ultra-capacitor is installed then it requires 1 time battery replacement in total lifetime. So, total cost of 1 time battery replacement and Ultra-capacitor installation = 205 USD which is approximately equal to 3 times battery replacement cost. So, the installation of Ultra-capacitor doesn't require extra cost.

### 2. 4. Feasibility analysis of the proposed vehicle

#### 2. 4. 1. Cost analysis & payback time

Micro hybrid system installment cost approximately 300 to 400 USD [9]. Normally Auto-rickshaw (Engine driven Three-wheeler) runs at 30 km/hr & per day runtime 4 hours (estimated) in Bangladesh.

Let Fuel consumption be 30 km/ltr. 1 liter diesel costs 100 taka = 1.23 USD. For 4 hour runtime costs = 4.92 USD. For using, Start-Stop system Fuel economy gains in the range of 5-10% [9, 10]. Taking, 6%, so amount of fuel saved = 0.24 liter/day costing approximately 0.2952 USD. So, Payback Time = (Micro hybrid system installment cost/per day saving) = 1186 days = 3.24 years.

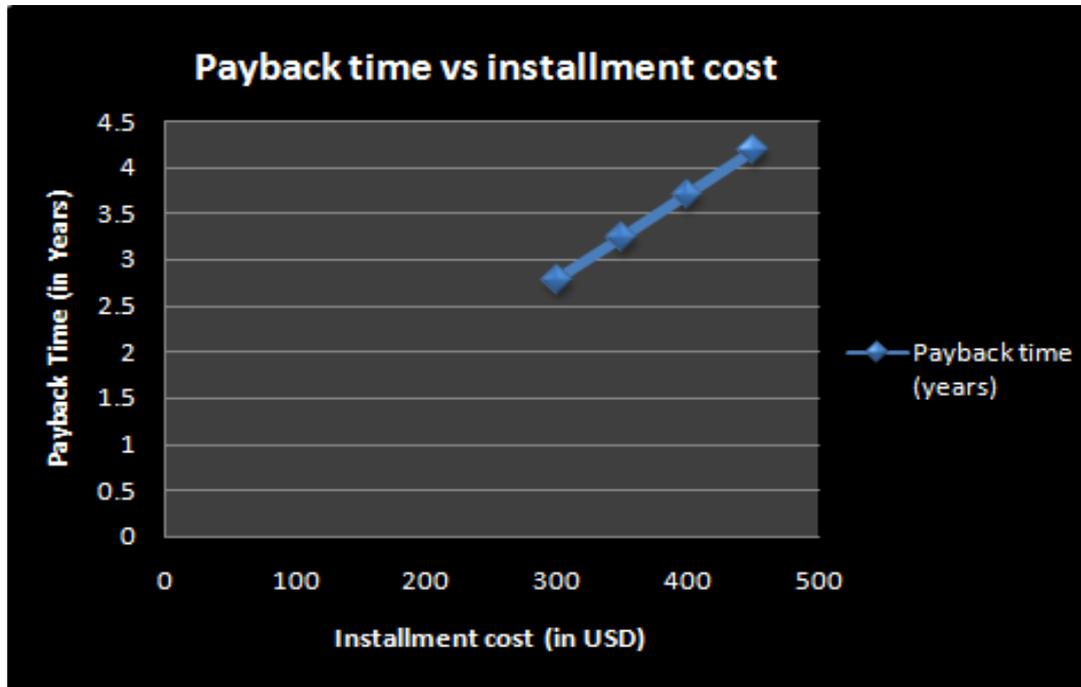


Figure 6. Payback time depending on installment cost.

#### 2. 4. 2. Environmental Impact

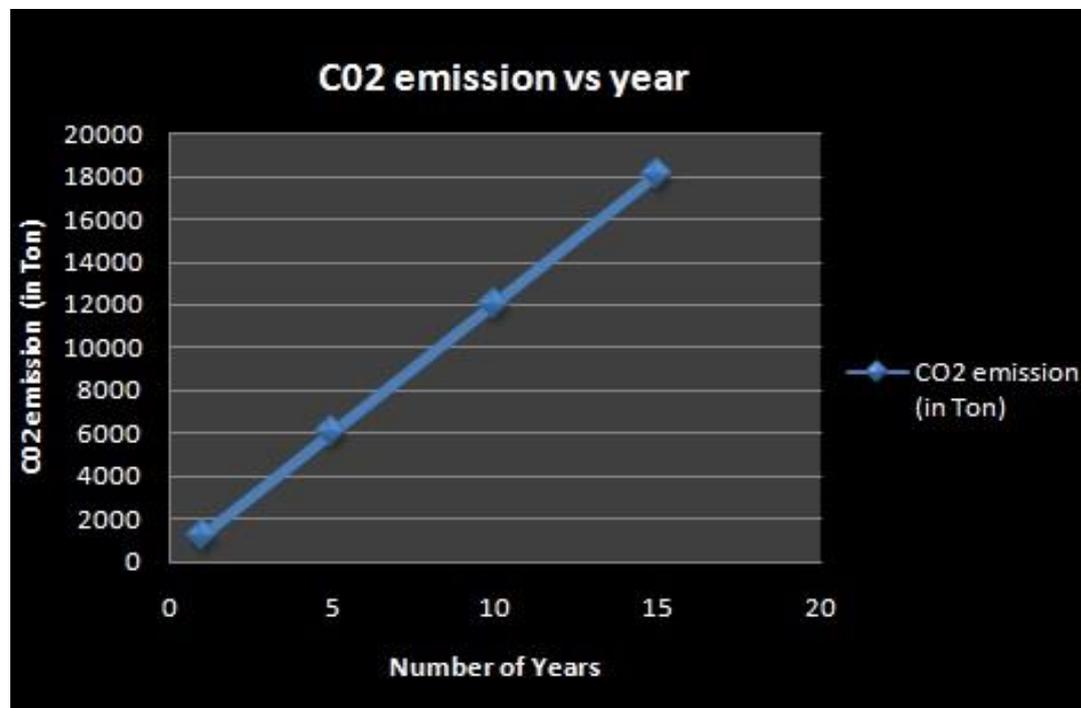


Figure 7. CO<sub>2</sub> emission reduction in terms of year.

Assuming, auto-rickshaw runs approximately 120 km/day with a fuel consumption of 30 km/ltr. Then the fuel consumption is 4 liter per day. So, the corresponding CO<sub>2</sub> emission = 4 ltr/day. It terms to, 2.5 kg/ltr = 10 kg/day. The system would save 6% fuel (estimated). So, per day fuel saving 0.24 liter. In Dhaka city, the number of auto-rickshaw is approximately 5000. So, total amount of fuel saving in Dhaka city would be = 1200 liter/day and the corresponding CO<sub>2</sub> emission will reduce by = 3000 kg/day. CO<sub>2</sub> reduction cost in Asian market = 29.5 USD/1000 kg.so, per day will be saved = 88.5 USD and annually it would 32,302.5 USD.

## **2. 5. Advantage of proposed mechanism**

- 1) In city driving fuel consumption is reduced up to 5% to 10%.
- 2) CO<sub>2</sub> emissions are decreased by up to 5% to 10% in city driving; nearly the same as the pickup from efficiency.
- 3) The engine restarts within 350 milliseconds in complete silence.
- 4) Wipe out engines commotion and vibrations when the vehicle is at a transitory Standstill, which speaks to 35% of city driving time.
- 5) Execution cost is very less compared to other systems. (The most part in go \$300-\$400)
- 6) The engine restarts automatically.

## **3. CONCLUSIONS**

Over half autos from 2013 are utilizing start-stop innovation of micro hybrid system. Ultra-capacitor is utilized alongside battery in micro hybrid setup and it is utilized as a part of three-wheelers then it won't just lessen fuel consumption yet in addition CO<sub>2</sub> emission in a satisfactory rate. In Asian urban communities like Bangladesh, India, Japan and so on a large number of auto-rickshaw keeps running out and about every day. In the event that all the auto-rickshaw is taken under this framework then a gigantic measure of cash can be spared. All the said advantage is given by the framework without trading off vehicle efficiency and consumers comfort.

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