

Pollution Reduction Mechanism Model in Urban India using Solar Assisted Bicycle

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Abstract

Objectives: The main objective of this study is to design and develop a Solar Assisted Bicycle (SAB) in order to reduce pollution in India. **Methods/Statistical analysis:** The elicitation design and methodology to move or run the bicycle in solar energy with the help of hub motor which is mounted on the front wheel. Provision is made in the design to charge the battery from electrical (solar) source. **Findings:** Thus the rapid growth in population and urban mobilization in India has result an increase in the usage of motor vehicles. The environmental decay is due to vehicles combustion of fuels. In urban areas it is increasing continuously day by day. Even though India has abundant resource in solar energy, still the country is spending more of artificial resource (crude oil) than natural resource (Solar). To solving this problem, a design is made to develop an eco-friendly vehicle. The main finding of the proposed bicycle is to reduce the 60% of overall vehicle emission in India. **Application/Improvements:** with the rising fuel prices and pollution, this bicycle seems to be cheapest, healthiest, eco-friendly and it is affordable to all kinds of people in the society.

Keywords: Air Pollutant, Eco-Friendly, Hub Motor, Solar Assisted Bicycle(SAB) , Vehicle Emission

1. Introduction

As of 2015, over 60% of the India population lives in urban environment. The increased Mobility comes up with high price and needs personal transportation vehicles instead of walking. However India was the sixth largest motor vehicle manufacturers produced a record 23.4 million motor vehicle in 2014-15. Two wheeler production reached 18.5 m units in the same year. The growth of vehicle is doubled in last two decade. Traditionally, these vehicles have been predominately powered by fossil fuels. Vehicles become major source of pollutant in urban India. The major air pollutants emitted from vehicles are Carbon Monoxide (CO), Oxides of Nitrogen (Nox) and Particulate Matter (PM)¹. It is important to distinguish how such pollution is affecting the country. Various government-run programs established throughout the country to reduce vehicle emissions. These program gets failure because lack of infrastructure problem for implementing. The overall vehicle population shown in Figure 1.

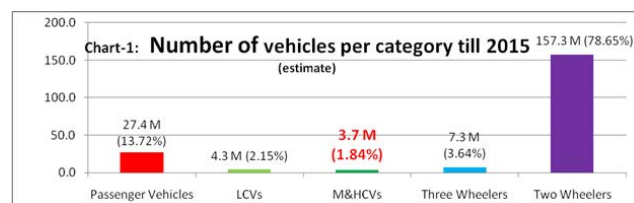


Figure 1. Overall vehicle population.

The increasing air pollution is affecting environment and adverse health effects like lung cancer, cardiovascular morality, and 10% deaths in the country per annum². To overcome this problem, an effort is being made to put forth for the developing an eco-friendly vehicle to reduce pollution in India. The SABs provide an alternative means of personal transport.

Literature review in books and electronic media given a brief explanation about e-bikes and various inventive measures they are of Electric bicycle that was propelled by double electric motor invented by Boston. This model was later re-invented with the design hub of the crankshaft axle in 1990 by giant lafree e-bikes.

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In 1992, Japan based company vector services limited were established an e-bike included NiCad batteries³. The production increased from 1993 to 2004 estimated 35%. The e-bike and power bikes were commonly used because the powerful models were develop to reach the speed up to 80 km/h (50 mph) in the year 2001. In major Chinese cities, among two wheeler vehicles 10% to 20% of e-bikes were on the street in the year 2007. Nowadays by upgrading e-bikes worldwide, the small motor is introduce to assist the rider pedal power which brings more power to e-bikes that is closely functioned to moped style⁴. In Germany and china the e-bike company gained popularity compared to conventional mopeds.

The Rapid diffusion of electric vehicle will increase the electricity demands. However, this will not require capacity addition.

2. Design and Development

2.1 Methodology

This methodology is design a SAB as shown in **Table 1**.

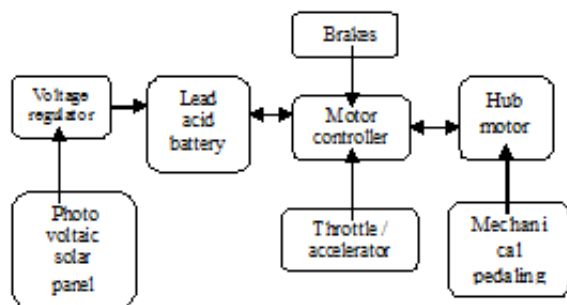


Table 1. Block diagram of a solar powered bicycle

2.1.1 Hub Motor

The hub motor is a Brushless DC (BLDC) motor. Inside the hub surface an array of permanent magnet is placed. Both the windings are attached to the front axle and the alternating current produced by these windings is helps to rotate the hub. The spinning windings gains electricity from the carbon brush via comitatus plate⁵. The permanent magnets which mounted on inside of the hub and the motor are outside the stator. The hub motor is mounted on front axle of the bicycle which helps to rotate the wheel. The Hub motor is shown in Figure 2.

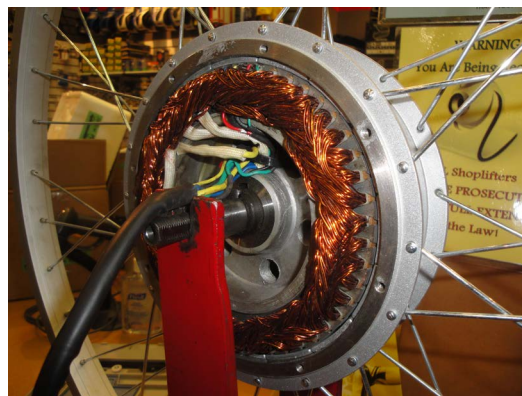


Figure 2. Hub motor.

2.1.2 Solar Panel

Solar panel is a device that collects and converts solar energy into electricity or heat⁶. The Photo voltaic effect involves the creation of a voltage into an electromagnetic radiation⁷. The solar panel is used depending upon the usage of bicycle. The solar panel shown in **Figure 3**.



Figure 3. Solar panel.

2.1.3 Accelerator

The accelerator is necessary to vary the speed at different traffic and road conditions. The accelerator is connected to controller of the hub motor and it is fitted on the handle bar. The accelerator is used to run the motor at different speeds by changing battery voltage to an alternating voltage with varying frequency and amplitude^{8,9}.

2.1.4 Battery

The battery is used to store the energy from solar panel¹⁰.

The lead acid battery is used for this vehicle because of their efficiency, performance and standby for this particular application. Also it stores the high capacity of the energy.

3. Principle

When the power supply given to the hub motor from solar panel unit, the bicycle wheel rotates to move. The bicycle rider can choose either a motor or pedal or otherwise the both at same time. Purpose of a solar powered bicycle is to introduce the new eco-friendly vehicle using solar energy¹¹. The prototype model of SAB as shown in Figure 4.

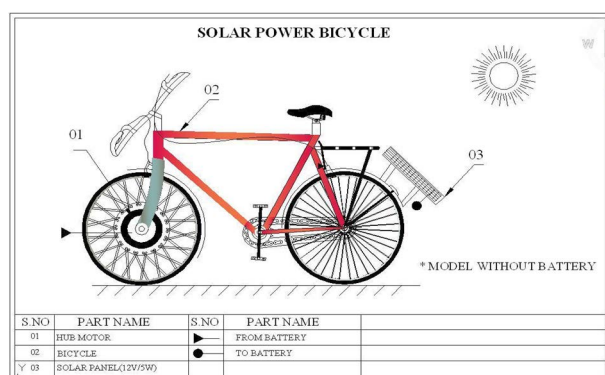


Figure 4. Prototype of SAB.

4. Motor Vehicle Population and Pollution in India

In India, vehicles population due to increasing population of peoples in urban areas, which has led to growing cities, increase in traffic, rapid growth, growing economic development and industrialization. About, 9-10 million vehicles produced annually in the country¹². Vehicle growth rate is the backbone of economic development in our country. The overall vehicles population is increased year by year from 154.8 million in 2010 to 204.6 million

in 2015. From that motor vehicles (two wheelers) population is from 117.6 million in 2010 to 164.09 million in 2015, of which rapid growth in two wheelers which is approximately 75% of overall vehicle population¹³. In urban India, major air pollution is contributed by vehicular emission motor vehicles are of great concern. The vehicles sector emits an estimated 271 tonnes of CO₂, of which is contributed by road transport. The major pollutants emitted from road transport are Carbon Dioxide (CO₂), CO, NO_x, Nitrous Oxide (N₂O), Sulfur Dioxide (SO₂), Volatile Organic Compounds (VOCs), PM and Hydro Carbon (HC). This vehicle pollution rate is different and depends on the production year of vehicle and condition of their technical maintenance. Some of the registered two wheelers population in India during 2010-15¹⁴ as shown in Table 2.

Table 2. Registered motor vehicles in India

Year	No. of motor vehicles (in millions)
2010-11	117.6
2011-12	134.07
2012-13	137.96
2013-14	148.09
2014-15	157.3
2015-16	164.07

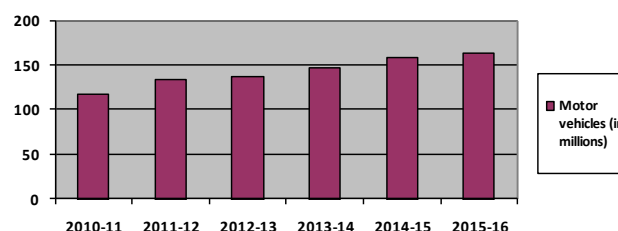


Figure 5. Registered motor vehicles in India .

4.1 Emission Estimation

Emission from the vehicles mainly depends on the fuel. The emission is estimated on the basis of no of vehicles in

Table 3. Emissions from different vehicles in India

Categories	CO ₂	CO	NO _x	SO ₂	PM	HC
Bus	28748.16	207.26	679.73	79.24	31.36	51.72
2 wheeler	8701.08	719.64	62.15	4.25	16.36	464.49
LCV (passenger)	4378.10	370.29	92.93	2.11	14.52	10.16
LMV (goods)	44654.58	442.04	110.94	123.02	17.33	12.13
Cars and jeep	23901.22	212.30	22.14	5.67	3.22	38.01
Others	5705.22	57.41	64.54	32.19	3.98	8.96

every region and distance travelled per vehicles in a year. The major pollutants emitted from the vehicles are CO_2 , CO , NO_x , SO_2 , PM, HC. Among different types of vehicles, two wheelers emit major pollutant in the country¹⁴. It is given in following equation.

$$E_i = \sum (V_j * D_j) * E_{ij}$$

Where, E_i = Emission of compound

D_j = Distance travelled per vehicle in a year

V_j = number of vehicle

$E_{ij.km}$ = emission from vehicle type per Driven type

4.2 Different Type of Vehicle Emission Estimated

The emission of different types of vehicle is calculated¹⁵ and shown in Figure 6. and Table 3. The estimated emission in major Indian cities¹⁶ by pollution load metric ton per day as shown in Table 4.

Table 4. Estimated pollution load in major Indian cities

City	Pollution load in metric tons per day			
	CO	NO_x	HC	PM
Delhi	421.84	110.45	184.37	12.77
Chennai	177.0	27.30	952.64	7.29
Mumbai	189.55	46.37	89.93	10.58
Kolkata	137.50	54.09	47.63	10.80
Bangalore	207.04	29.72	117.37	8.11

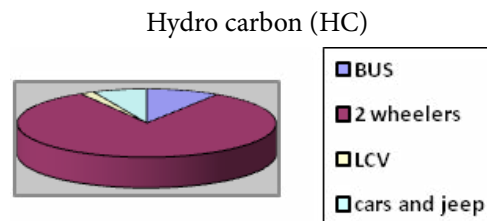
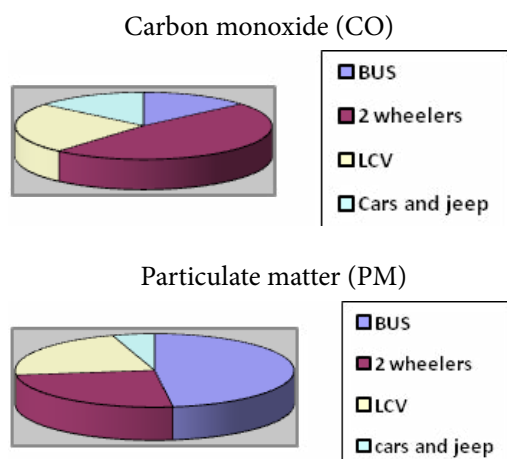


Figure 6. Before using SAB vehicle-wise emission pollutants.

5. A Solar Bicycle Solution

In India, two wheelers will continue to dominate as a major mode of transports in cities. The current stock of motorized two-wheelers uses petrol driven internal combustion engine. The petroleum products are the preferred fuels for the transport sector because of their high energy density and low cost. Various studies revealed that motor vehicle emissions which results in environmental decay and adverse health effects like lung cancer, asthma and cardiovascular mortality etc.

Apart from the issues above mentioned, much research worldwide has been conducted on solar-mobility solutions, especially increased CO , CO_2 emissions during recent years and environmental decay on consequences of fossil fuels. It is possible to propose a model and procedural solution to reduce pollution. Then it is carefully analysed and proposed a mechanism model of SAB in the country¹⁷. The adoption of solar bicycle usage can reduce the two wheelers emissions like CO , HC, and PM etc. Moreover a solar bicycle reduces the 60% of the overall vehicle pollution and caters the needs of all kinds of people in the country. It is analysed that after using SAB vehicle the reduction of two wheeler pollutant as shown in Figure 7.

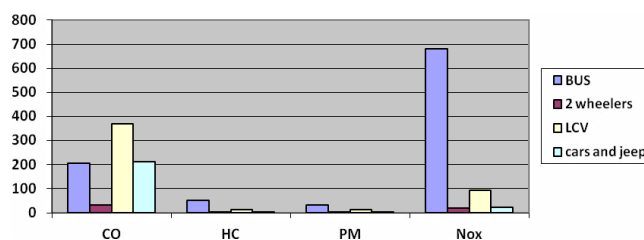
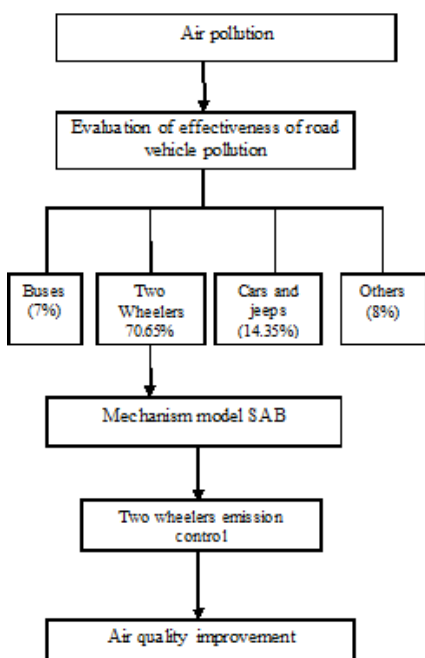


Figure 7. After using SAB vehicle wise emission pollutants.

5.1 Pollution Reduction Process

The pollution reduction process by implementing the mechanism model SAB as shown in Table 5.



6. Results and Discussion

Parameters	2 - Wheeler	SAB
Max. speed limit (km/h)	60-75	40-45
Operating cost for every 40 kms (depending upon vehicle) in Rs	60-65	Nil
Type of energy used	Petrol	Solar
Peddalling	No	Yes (if necessary)
Pollution reduction	No	Yes
Initial cost in Rs	40000- 75000	15000-20000
Comfort for all	No	Yes

7. Conclusion

This paper tells about the methodology to modify the existing bicycle into solar energy bicycle. It is simple in construction, cheaper and affordable to all kinds of people. Moreover the bicycle can run free of cost by solar energy and does not need any fossil fuels thereby saving the currencies. By using this bicycle, it reduces the two wheelers pollution (reduces 60% of overall vehicle pollution) and environmental decay in the country.

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