

## Electricity from Wasted Energy of the Moving Vehicle Using Speed Breaker

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### Graphical abstract



### Abstract

Industrialized modern world consumes vast amount of energy mostly in the form of electrical energy. From recent statistics on global warming, fuel shortage, pollution, problems with nuclear power and deregulation of electrical energy indicates that failure of investigating new energy sources to generate electricity can cause a huge power crisis in the near future, especially for people of developing countries like Bangladesh. Therefore, to meet future energy demand, it is must to implement some new ideas for optimal utilization of conventional sources through conservation of energy. This research shows a way to utilize the energy in the form of jerking pressure which is wasted during the vehicles passes over a speed breaker. Normally, a lot of energy is produced due to jerking which can be tapped and converted to electricity by using a simple mechanism called roller mechanism very easily and efficiently. The amount of generated electricity depends on the number of vehicle and weight of the vehicle passing over the speed breaker. Due to the high increasing rate of vehicle number day by day, this system can fulfill the demand of electricity of a small area, very effectively and can be treated as a mini power plant for an individual area.

*Keywords:* Battery, energy conversion, power hump, roller mechanism, speed breaker, street lamps, wasted energy

### Abstrak

Industrialized modern world consumes vast amount of energy mostly in the form of electrical energy. From recent statistics on global warming, fuel shortage, pollution, problems with nuclear power and deregulation of electrical energy indicates that failure of investigating new energy sources to generate electricity can cause a huge power crisis in the near future, especially for people of developing countries like Bangladesh. Therefore, to meet future energy demand, it is must to implement some new ideas for optimal utilization of conventional sources through conservation of energy. This research shows a way to utilize the energy in the form of jerking pressure which is wasted during the vehicles passes over a speed breaker. Normally, a lot of energy is produced due to jerking which can be tapped and converted to electricity by using a simple mechanism called roller mechanism very easily and efficiently. The amount of generated electricity depends on the number of vehicle and weight of the vehicle passing over the speed breaker. Due to the high increasing rate of vehicle number day by day, this system can fulfill the demand of electricity of a small area, very effectively and can be treated as a mini power plant for an individual area.

*Kata kunci:* Battery, energy conversion, power hump, roller mechanism, speed breaker, street lamps, wasted energy

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### 1.0 INTRODUCTION

Now-a-days one of the severe problems on earth is energy crisis and environmental deterioration because of the lesser availability of energy in 21st century. The increasing rate of energy consumption will be more day by day because of the increasing rate of world population. The high interaction between energy and environment prohibits the use of fossil fuel which causes Green House Gas (GHG) effect on earth's environment. One of the effective ways to solve this huge problem of energy crisis is the use of renewable energy and sustainable energy more and more. In a

developing country like Bangladesh, energy source crisis to generate electricity is a major issue which almost hampers all developments. In Bangladesh only about 32% of the total population has access to use electricity and 6% to natural gas. But in rural area only 22% has electricity without gas supply [1]. Because of the high consumption rate of fossil fuel, it will be over near future. Crude oil consumption has increased radically from recent observation which mostly used to generate electricity. Bangladesh imports 3.5-4.0 million tons of petroleum and petroleum products per year that spent about \$5 million in 2011 which is 10% more expense compare to year 2000 [1]. A

developing country like Bangladesh can't afford this strong dependence on foreign oil in the near future without thinking any alternative way. For alternative solutions the existing renewable energy sources like biomass, hydro, solar, wind and tidal energy are needed to build up in a more useful manner to minimize the present energy shortage. Though from year 1850-2005 production and use of traditional energy increases more than 50% with a total of approximately 0.2 billion toe to 11.4 billion toe (IEA, 2007) mostly in industrialized nations [2]. In last few decades, electricity demand has increased significantly, due to the industrialization and increasing standard of living of the human being. But correspondingly electricity generation has not kept with demand as yet. To fulfill this huge demand of electricity alternative sources must be used like solar, wind, tide etc. very effectively. Though efficiency level of these energy sources are not to the mark for minimizing electricity shortage. Recently a new way is introduced to generate electricity from road speed breaker by using a roller fitted in the road and vehicle passing over speed breaker are the source of generating electricity [3]. Where, vehicle mechanical energy is converted to electrical energy very efficiently which is also called power hump. Previously some other mechanism like Rack-pinion, crank shaft and spring is used to generate electricity from road speed breaker [4-13]. But these mechanisms are not suitable to provide electricity in any whole area effectively.

**2.0 METHODOLOGY**

Energy is one of the prime needs for every human being. That's why energy is always converted from one form to another very rapidly for human necessity. In this age of modern industrialization, energy demand increases due to the increase of population at an alarming rate. Electricity is one of the essential forms of energy but most of the people of the developing country are deprived of this energy. Main reason behind this is energy sources for electricity like oil, gas are diminishing quickly. So, to sustain we must have to find some other energy sources. In this research, electricity is captured from road speed breaker where large number vehicle passes over the speed breaker are the non-conventional source of the electricity. It can be treated as the optimal use of available energy in front of us. The number of vehicles in roads is increasing day by day. So, there is a large possibility of tapping the energy and generating electricity by making the speed breaker as one of the small power generation unit. In the roller mechanism, a roller is fitted in the road which can rotate. Whenever vehicle passes over this rotating speed breaker rotates, so vehicle kinetic energy is converted to the rotational energy which can be called a form of mechanical energy and depicted in Fig. 1.

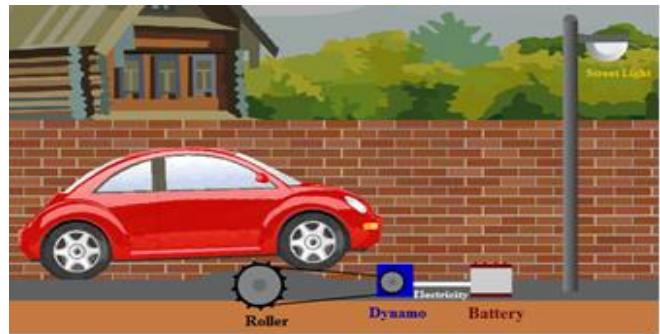


Fig 1 Conversion of kinetic energy to rotational energy [3]

This generated mechanical energy can be easily converted to electrical energy by using dynamo or DC generator where shaft of the roller is coupled with the shaft of the dynamo with some gear ratio for gaining mechanical advantage to generate electricity. This conversion is depicted in Fig. 2. As the number of vehicle passes over the speed breaker increases correspondingly increases the generation of mechanical energy which can be converted to large amount of electricity. This electricity can be easily used to lighten street lights, traffic signals and residences nearer to the road.

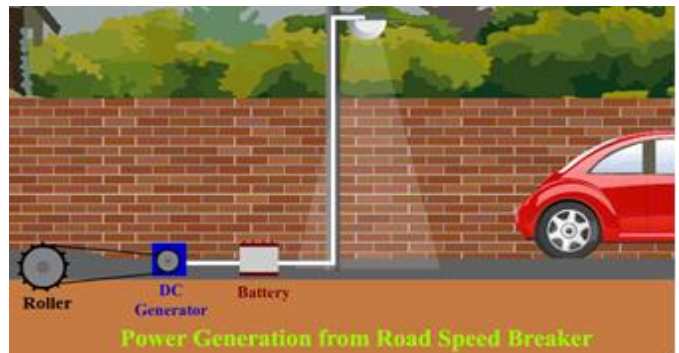


Fig 2 Conversion of mechanical energy to electrical energy [3]

**3.0 MODEL DESIGN**

For this system a block diagram is displayed in Fig. 3.

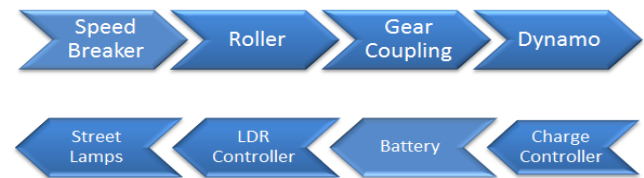


Fig 3 Total system block diagram

The schematic arrangement of the system equipment's from top and the coupling between roller and dynamo shaft through chain drive from side is shown in Fig. 4.

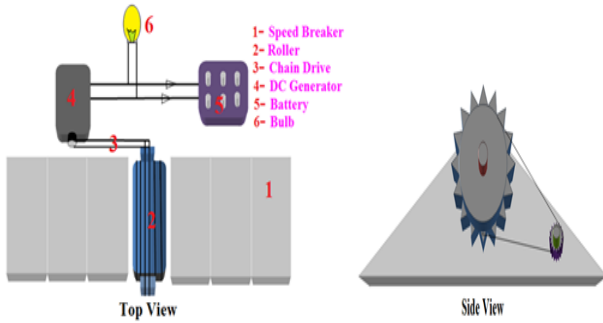


Fig 4 Connection diagram of the system [3]

For constructing such system roller plays an important role to generate more electrical energy. In this research, notch type roller is used whose layout design is depicted in Fig. 5. Notch type roller is used for getting higher number of rotation and gripping.

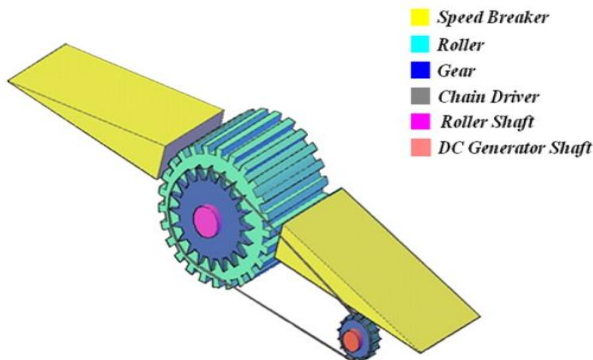


Fig 5 Design layout of the system [3]

4.0 CONSTRUCTIONAL DETAILS

All the equipment used in this research to construct the system arrangement is displayed in Fig. 6

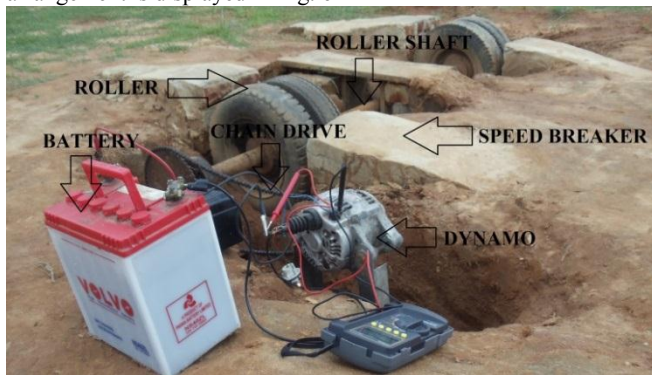


Fig 6 Equipment used in the system implementation [3]

4.1 Speed Breaker Arrangement

Speed breakers are used to slow down the speed of vehicle by offering a resistance on wheels. The height of the speed breaker and the placement of roller as a speed breaker should be well managed for this system. Height of the speed breaker should not exceed 8 inch from ground level and there must be a gap between roller and speed breaker to rotate freely when vehicle passes over the speed breaker [3].

4.2 Roller Description

The Roller have to take all the load of the vehicle, so iron made roller is used and outer surface of the roller is covered by rubber to provide gripping to rotate across its shaft [3].

4.3 Gear

Gear is a mechanical rotating machine part having cut teeth, which mesh with another toothed part to transmit torque and produce a mechanical advantage through a gear ratio. In this research, gear ratio of 1:4 is used [3].

4.4 Chain Drive

Chain drive is one kind of mechanical technique for transmitting generating mechanical power from one to another. Usually chain drive is used to convey power to the wheels of a vehicle like bicycle and motorcycle.

4.5 Dynamo or DC Generator

A dynamo (12V) is an electrical generator that produces direct current from faraday’s electromagnetic induction law with the use of a commutator. The generator converts mechanical energy of prime mover to electrical energy which can be stored in battery [3].

4.6 Battery

In this research, a battery of 32Ah is used to store electrical energy which can deliver power to the load when required [3].

5.0 SYSTEM IMPLEMENTATION

This whole system was implemented in Chittagong University of Engineering and Technology (CUET), Chittagong-4349 of Bangladesh to introduce this new technique. During the system implementation an auto-rickshaw (CNG) is used as a vehicle which is shown in Fig. 7.



Fig 7 Implementation of the system using vehicle (CNG)

6.0 EXPERIMENTAL DATA ANALYSIS

6.1 Data Collection

In this research, data collection is very important for accurate output power calculation. For this reason, complete implementation process is divided by several steps depending on

the time of passing speed breaker by vehicle. Considering, a vehicle passes over the speed breaker loaded by two passengers. Before the passing of the speed breaker by vehicle no power is developed because of any rotation of the roller. Fig. 8 shows zero current and very low voltage (nearly zero voltage) correspondingly at this instant.



Fig 8 Output before passing vehicle over speed breaker

Then after a fraction of time, when vehicle has just passed the speed breaker as a result a high torque is induced in roller which tends to rotate the roller. Due to this high torque, maximum number of rotation is induced in the roller. This rotation produces maximum terminal voltage and causes charging current to flow towards battery which is depicted in Fig. 9.



Fig 9 Output after passing vehicle over speed breaker

So, the battery is charging with a high terminal voltage which corresponds to high power during this process. The developed power starts decreasing whenever rotation of the roller decreases after the passing of vehicle over the speed breaker. But, in a busy road there will be traffic which tends to a continuous rotation of the roller and as a result continuous charging of battery is very much possible. So, in Table I, several experimental data with various observations are shown which are taken in between a charging period of 4 seconds for one vehicle passing over the speed-breaker.

Table 1 Experimental data for one vehicle passing

Observation No.	Voltage (V)	Current (A)	Power (W)
01	0.801	0	0
02	12.67	0.5	6.335
03	12.68	0.8	10.13
04	12.75	1.7	12.75
05	12.79	2	25.58
06	10.66	2.1	22.386
07	10.60	2.2	23.32
08	10.72	2.3	24.66
09	10.69	2.5	26.725
10	2.905	2.6	7.54
11	1.821	1.3	2.367
12	1.632	0.9	1.469
13	1.243	0.65	0.807
14	0.904	0.5	0.452
15	0.721	0.41	0.2956

6.2 Data Analysis

In this research, the experimental data were taken by using an auto-rickshaw (CNG) as a vehicle for different types of load (kg) where loads are varied in Table II by changing the number of passenger.

Table 2 Experimental data of the implementation

Vehicle Load (kg)	Generated Voltage, $V_T$ (V)	Power (W)	Charging Period (sec)
255	9.86	7.34	3.87
290	11.23	8.14	3.94
306	11.85	8.47	4.04
375	12.75	9.52	4.12
404	13.12	10.21	4.18
435	13.69	10.76	4.21
465	13.84	10.83	4.20
486	14.21	11.13	4.16
534	14.91	11.43	4.22

7.0 RESULT ANALYSIS

7.1 Theoretical Analysis [14]

An Auto-rickshaw (CNG) with one passenger,  
 Vehicle mass,  $M = 435$  kg  
 Height of roller above speed breaker,  $d = 2$  inch. = 5 cm  
 Mass of roller,  $m = 60$  kg  
 Roller radius,  $r = 6$  inch. = 15.24 cm  
 No. of rotation per minute for roller =  $N_1$   
 No. of rotation per minute for dynamo shaft =  $N_2$   
 Gear ratio =  $N_1/N_2 = 1/4$   
 When vehicle passes over the speed breaker induced torque on roller,  $\tau = \text{Force} \times \text{Distance} = M \times g \times 0.05 = 213.15$  Nm  
 Again Induced Torque in Roller  

$$\tau = \text{roller mass} \times (\text{angular velocity})^2 \times \text{roller radius}$$

$$= 60 \times (2\pi N_1/60)^2 \times 0.1524$$

$$N_1 = 46 \text{ rpm}$$

$$N_2 = 4 \times N_1 = 184 \text{ rpm}$$
 If 15 vehicle pass in 1 minute, Number of rotation of dynamo shaft,  
 $N = 15 \times 184 = 2760$  rpm  
**Rating of the Dynamo used,**  
 Rated Voltage  $E_{A0} = 12$ V, RPM=1800,  
 Current capacity = 35 A

Internal generated voltage  $E_A$  is obtained from Fig. 10 using the equation,

$$E_A/E_{A0} = N/N_0$$

$$E_A = (N \times E_{A0})/N_0 = 14 \text{ V}$$

Armature Current,  $I_A = \text{Load Ampere Hour (Ah)}/60$   
 $= 35/60 = 0.583 \text{ A}$

Terminal voltage,  $V_T = E_A - I_A R_A = 17.8 \text{ V}$

Output Power =  $V_T I_A = 10.2 \text{ watt}$ .

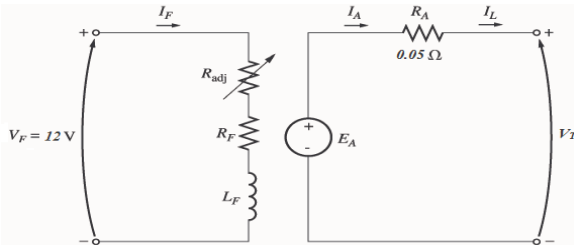


Fig 10 Internal diagram of dynamo

So, 1 vehicle pass in 4sec over the speed breaker power generated  $(10.2 \times 4 \times 15)/60 \text{ watt} = 10.2 \text{ watt}$

Now, total minute of a day =  $24 \times 60 = 1440 \text{ min}$

Considering useful minute in a day = 400 min

Power generated in 400 min =  $400 \times 10.2 = 4080 \text{ watt}$ .

## 7.2 Practical Analysis [8]

In this research, average 4 seconds charging period is found though this charging period increases with the increase of vehicle load. Variation of output power with the load variation is depicted in Fig. 11. So, this system will be very effective for highly loaded vehicle.

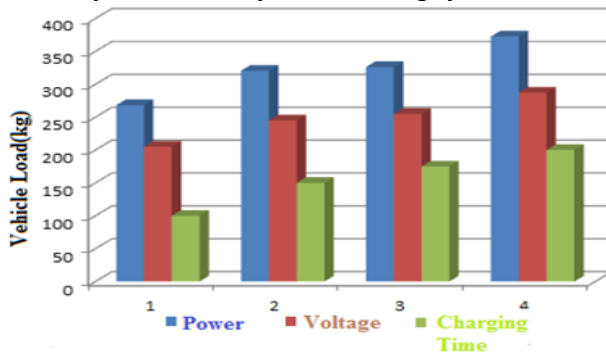


Fig 11 Variation of voltage, current and power to the time  
 Mean generated Power =  $161.4/15 = 10.76 \text{ watt}$

## 8.0 CASE STUDIES

Considering a traffic location of a city area where total number of vehicle passing in a day is 5000. If this project is implemented on this location, then the power obtained from the system can be calculated. Now to do so, two kinds of roller can be designed depending on types and weight of the vehicle. To make the process more effective, the road is should be divided in such a way that, in one way the light vehicle will pass and on the other way the heavy vehicle will pass.

### A. For light vehicle (up to 1 ton or 1000kg):

Considering number of light vehicle = 3500

Now, the weight of the roller = 100 kg

In the road of light vehicle for an Auto-rickshaw (300kg),

$N_1 = 29.6 \text{ rpm}$

$N_2 = 4 \times N_1 = 4 \times 29.6 = 118.4 \text{ rpm}$

Now,  $E_A = 12.63 \text{ V}$

Terminal voltage  $V_T = E_A - I_A R_A = 12.6 \text{ V}$

Output Power =  $V_T I_A = 7.31 \text{ watt}$ .

In this road for a car (300kg),

$N_1 = 51.33 \text{ rpm}$

$N_2 = 4 \times N_1 = 4 \times 51.33 = 205.32 \text{ rpm}$

Now,  $E_A = 12.3 \text{ V}$

Terminal voltage  $V_T = E_A - I_A R_A = 12.27 \text{ V}$

Output Power =  $V_T I_A = 12.27 \times 0.58 = 7.12 \text{ watt}$ .

### B. For heavy vehicle (above 1 ton or 1000kg):

Considering number of light vehicle = 1500

Now, the weight of the roller = 500 kg

In the road of heavy vehicle for jeep (2000kg),

$N_1 = 40.5 \text{ rpm}$ ,  $N_2 = 4 \times N_1 = 4 \times 40.5 = 162 \text{ rpm}$

Now,  $E_A = 12.96 \text{ V}$

Terminal voltage  $V_T = E_A - I_A R_A = 12.93 \text{ V}$

Output Power =  $V_T I_A = 12.93 \times 0.58 = 7.5 \text{ watt}$ .

## 9.0 POWER CALCULATION

In this research, as a light vehicle, maximum number of vehicle is auto-rickshaw and the rest of is car and mini bus etc.

So, useful power for auto-rickshaw is =  $7.31 \times 400 = 2924 \text{ W}$

useful power for car =  $7.12 \times 200 = 1424 \text{ W}$

useful power for jeep =  $7.5 \times 100 = 750 \text{ W}$

Now, total power generated = 5114 W.

For the overall system single roller can be used.

Now the weight of the roller = 300 kg

In this road for Auto-rickshaw(300kg),

$N_1 = 17.13 \text{ rpm}$ ,  $N_2 = 4 \times N_1 = 4 \times 17.13 = 68.5 \text{ rpm}$

Now,  $E_A = 12.33 \text{ V}$

Terminal voltage  $V_T = E_A - I_A R_A = 12.3 \text{ V}$

Output Power =  $V_T I_A = 12.3 \times 0.58 = 7.13 \text{ watt}$ .

In this road for mini bus (1000kg),

$N_1 = 37 \text{ rpm}$ ,  $N_2 = 4 \times N_1 = 4 \times 37 = 148 \text{ rpm}$

Now,  $E_A = 12.83 \text{ V}$

Terminal voltage  $V_T = E_A - I_A R_A = 12.8 \text{ V}$

Output Power =  $V_T I_A = 12.8 \times 0.58 = 7.42 \text{ watt}$ .

In this road for truck (5000kg),

$N_1 = 70 \text{ rpm}$ ,  $N_2 = 4 \times N_1 = 4 \times 70 = 279.8 \text{ rpm}$

Now,  $E_A = 13.05 \text{ V}$

Terminal voltage  $V_T = E_A - I_A R_A = 13.02 \text{ V}$

Output Power =  $V_T I_A = 13.02 \times 0.58 = 7.56 \text{ watt}$ .

So, useful power for auto-rickshaw is =  $7.13 \times 50 = 356.5 \text{ W}$

useful power for mini bus is =  $7.42 \times 200 = 1484 \text{ W}$

useful power for truck is =  $7.56 \times 100 = 756 \text{ W}$

Now, total power generated = 2596 W.

From the above calculation, it is clear that, power generation is much better in two way system than the one way system. But the cost is higher in two way system than the one way system. Overall, it is clear from above discussion that the roller design by dividing road is more effective.

## 10.0 FUTURE ASPECTS

This research shows a process to utilize conventional sources in a more effective manner without using natural resources. As it is known that, utilization of energy indicates the growth of a nation, so this represents a country's technological advancement also. In the near future, due to the increasing rate of electricity shortage in developing countries like Bangladesh this kind of research will prove a great boon to the world, because it can capture a lot of electrical energy from wasted energy which can be easily used for minor needs like lighting roads lights. This research indicates that

power generation is depended on the number of vehicle passing over the speed breaker. Now from Table III, it is clear that increasing rate of vehicle number is in higher order. So, this kind of mini power plant system is very beneficial for country like Bangladesh to meet their future electricity demand.

**Table 3** Number Of Year Wise Registered Motor Vehicles In Bangladesh [15]

Type of Vehicles	2010	2011	2012	2013	March 2014
Bus	27,778	29,539	30,978	32,085	32,391
Jeep	32,286	34,420	35,989	37,303	37,658
Microbus	66,379	70,430	73,474	76,011	76,957
Minibus	25,644	25,920	26,169	26,317	26,357
Taxicab	44,380	44,455	44,627	44,678	44,685
Truck	82,871	90,198	94,533	99,662	102,144
Auto-rickshaw	126,763	147,186	170,731	186,428	191,376

### 11.0 ADVANTAGES

This system has several advantages, such as [3]

- Energy is available all year around.
- It has simple construction, mature technology.
- Recognized as an uninterrupted power generation
- No manual work occurs during generation.
- Provides pollution free environment
- No consumption of any natural resources.
- No fuel transportation problem occurs.
- No obstruction to traffic.

### 12.0 CONCLUSION

In this modern age, advancement of a nation depends on the use of electricity by their people. But due to large population especially in the developing countries, the present power generation cannot meet the requirement. This causes a huge shortage of electricity and most of the people from developing country like Bangladesh are deprived from the advantages of having electricity and indicating a threat for near future. This research shows the feasibility of using a new technique named ‘power generation from road speed breaker’. Due to increasing rate of vehicle numbers in the road, this system

will be very effective to shorten the electricity crisis of a small area to some extent. If it is possible to supply an individual area through this kind of energy system by conserving natural resources, it will be beneficial for country’s future economic growth.

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