IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

Study Project on Transforming Highways into Renewable Resources Case Study on Mumbai-Pune Expressway (20Km Talegaon to Kamshet)

Abhishek C. Gaikwad [1], Aniket K. Chingunde [2], Shubham R. Mahajan [3], Ameya C. Dixit [4], A.K.Kadu [5]

Department Of Civil Engineering,

Padmabhooshan Vasantdada Patil Institute of Technology (PVPIT),

S No 33/22, Pune Pirangut Road, next to Chandani Chowk, Bavdhan, Pune, Maharashtra 411021,INDIA

Email ID:-

abhigaikwad5050@gmail.com, aniketchingunde1234@gmail.com, shubhammahajan520@gmail.com, ameyadixit72@gmail.com, avadhootkadu89@gmail.com

***Abstract* :** The major goal of this study is to make use of naturally accessible resources such as wind, sunlight, and rainwater on highways and roads. These resources meet all of humanity's basic needs in a more efficient manner. Electricity can be generated by utilizing wind energy in an efficient manner to produce the maximum amount of electricity. In this approach, we can take advantage of moving automobiles on the highway. The vertical axis wind turbine will generate power by turning the wind velocity produced by the vehicle. Solar panels, which can be installed over wind turbines, play an important role in generating electricity. Road Rainwater harvesting is a relatively recent concept that allows people to use rainwater for various purposes rather than letting it to run off.

***Keywords*—**(natural resources, Vertical Axis Wind Turbine VAWT, Solar Panels, Road Rain Water Harvesting)

I - INTRODUCTION

Energy has long been acknowledged as a critical factor in economic progress. The primary force in the cosmos is energy. Energy defines the biomes of the Earth and keeps life alive. All living things, from single-celled microbes to blue whales, are constantly consuming, using, and storing energy. As a result, renewable energy is required to meet the modern energy consumption demand. As a result, extracting energy from non-conventional sources, such as wind energy from vertical axis wind turbines (VAWT), solar energy from solar panels, and road rain water collection, is an essential part of energy production all over the world.

1.1 - Vertical Axis Wind Turbine VAWT: -

When autos go on highways/expressways, a pressure column is created on both sides of the road, generating wind energy. The imbalance of high pressure/low pressure energy band caused by automobiles creates this pressure column. The (VAWT) small turbines placed at the sides/center of these roadways convert kinetic energy to mechanical energy to electrical energy as a result of this pressure band wind flow and create pressure thrust.

This wind Pressure thrust depends upon the: -

- The intensity of the traffic
- The size of the vehicle
- The speed of the vehicle.

Fig no - 1 Vertical Axis Wind Turbine

1.2 - Solar panel: -

Solar energy is generated when solar panels are installed in an open area where the sun's heat radiation falls directly on the solar panels' solar cells, which then generate energy/electricity from the sun's radiation.

To make the most of the space available on the road site, these sorts of solar panels must be erected in the centre of the highway, between two lanes, above or beside the vertical axis wind turbine. These types of solar panel are need to be installed in the Centre in-between two lanes of the highways above or beside the vertical axis wind turbine to make the maximum utilization of the space available on the road site

Fig no – 2 solar panels

1.3 - Road rain water harvesting: -

The Road Rain Water Harvesting Technique can be used to collect rainwater and redistribute it to regions where it is useful. A road can function as either a water-guiding embankment or a rain-channeling drain. These features can be used to improve water management in a methodical way. The amount of water that may be gathered is determined by the rainfall pattern, the catchment area bounded by the road, and the land use and soil characteristics of the catchment region. A well-developed road drainage system is required for a road to operate as a water-harvesting mechanism, which can be accomplished by situating the road on an elevated embankment and creating an appropriate system of side drains or cross drains

Fig no – 3 Rainfall on Road

II - LITERATURE REVIEW

Niranjana.S.J: - investigated the power generation by vertical axis wind turbine. In this paper the power is generated by fixing the wind mill in the road highways. When the vehicle is passing through the road at high speed the turbine of the wind mill rotates and generates the power sources. This analysis that the vertical axis wind turbine can be able to attain the air from all the direction and produces the power of 1 kilowatt for a moment of 25 m/s. the efficiency of vertical axis wind turbine can be increases by modifying the size and shape of the blade.

Altab Hossain [2013] et al. showed a design that investigated the development of vertical axis wind turbines. The blade and the drag devices are designed in such a way that they are at a ratio of 1:3 to the wind turbine. The calculated output if this experiment is it produces 567W and 709W power when the wind speeds are 20m/s and 25m/s, respectively.

PiyushGulve [2016] et al. raised the design and construction of vertical axis wind turbines. This paper discussed the advantages of VAWT over HAWT. This paper indicates that the lea error on manufacture and friction loss, the higher efficiency. This loss can be minimized by designing the blades more aerodynamically.

Ben Dhan (2013): - All day long the transportation infrastructure receives solar energy from the sun rays, storing much of them as heat that is left to dissipate by nightfall. The concept of harvesting solar energy from transportation infrastructure is enticing because it offers a way to collect solar energy by utilizing an extensive infrastructure that already exists.

(Lee et al. 2010). Most significant approach would be harvesting solar energy from transportation infrastructures. For example, in the State of New Jersey most electrical poles along the highway have been equipped with rigid solar panel

Kiran Pal Kour 1, Loveneesh Talwar2 Vol. 8, Issue 10, and October 2019: - The intention of the study is to investigate the possibility of solar roads around the world. Solar road is a strained project in terms of constraint used. Solar roads are basically the roads made of high tensile strength material. Smart highways should be enhanced to develop the Nation and make the world go greener in a way that the consumption of fossil fuels would be totally eradicated Solar roadways use solar panels, PV effect LED"s and microprocessor chips with circuitry boards.

FRANK VAN STEENBERGEN, FATIMA ARROYO-ARROYO (2021): - Road infrastructure can be used to harvest water and redistribute runoff to areas where it can play a beneficial role. A road can act either as an embankment that guides water or as a drain that channels rainwater. These functions can be used to systematically enhance water management. The amount of water that can be harvested depends on the rainfall pattern, the catchment area enclosed by the road, and the land use and soil characteristics within the catchment area. For a road to act as a water-harvesting mechanism, the road-drainage mechanism needs to be well developed, which can be achieved by locating the road on an elevated embankment and constructing an appropriate system of side drains or cross drains, or by integrating suitable drainage structures into the road surface such as water bars and rolling dips.

Ministry of road transportation and highways (Dr.) Vijay Kumar Singh September, 2019: -One of the ways of improving the water table is to capture the rain water and utilize it for recharging of ground aquifers. It should be endeavor of all the Authorities including Highway Authority to contribute towards improving the ground water table and making available more storage of water for our needs. Ministry has already issued guidelines for the construction of rain water harvesting along National Highways vide circular dated so" September, 2013

J.R.Julius August-2013 - As the world population increases, the demand increases for quality drinking water. Surface and groundwater resources are being utilized faster than they can be recharged. Rainwater harvesting is an old practice that is being adopted by many nations as a viable decentralized water source. This paper reviews the methods, design of rainwater harvesting systems, and its impacts adopted in all parts of the world.

Naidu (2001) - in his study on Vanjuvankal watershed of Andhra Pradesh noticed that, because of water harvesting structures and percolation ponds the ground water level in watershed area showed a rise by 2 to 3 meters

Nissen-Petersen (2006). Thus, road harvesting can generate substantial positive impacts: more secure water supply, better soil moisture, reduced erosion and respite from harmful damage.

III - METHODOLOGY

3.1 - Vertical Axis Wind Turbine-

The VAWT is a device that produces electricity. This turbine is installed in the highway barrier. The vehicles on both sides of the divider speed up the wind, increasing its kinetic energy and forcing the turbine blades to spin. This produces electricity when linked to a DC generator.

3.2 - Procedure or Methodology of Calculation-

For this project, a turbine with a height of 1.35 meters and a diameter of 0.63 meters was used. The turbine's initial thrust is 1.5 meters per second. Each car passing on the highway causes the turbine to rotate, and the output power created by turbines installed along the 20km road length is computed using the average wind speed for one day, month, and year.

3.3 - Solar Panel-

To save space on the roads, the solar panel should be positioned above the turbine. The solar panel can create power at the same time as the wind turbine. The solar panel chosen for the study is 63.5cm*67cm*3.4cm in size.

3.4 - Procedure or Methodology of Calculation-

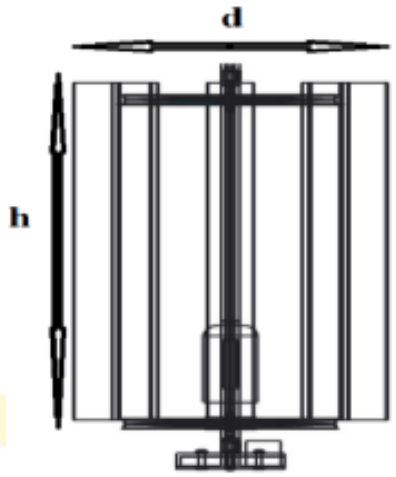
For the whole no solar panel installed 20km road patch, the amount of power created by each panel is determined by assuming 6 hours, 7 hours, 8 hours, 9 hours, 10 hours of sun light per day to compute the amount of electricity generated by the panel for one day, one month, and one year.

3.5 - Road Rain Water Harvesting-

Road Rainwater harvesting is a method of collecting and storing rainwater that falls on highways/roads rather than allowing it to runoff. Instead of letting the rainwater to runoff, we can store it and use it for necessary tasks. Roadside drains gather rainwater, which can then be stored in tanks via pipelines. We calculated the total collection of rain water for a 20km road patch in a year using the average yearly rainfall of Maharashtra

IV - CALCULATIONS

(4.1) Calculation Of vertical Axis Wind Turbine (VAWT)



- *Area of the turbine = d*h=0.63*1.35=0.85 square meters*
- *Average Wind Speed= 22 m/s*
- *Average Wind Speed of Rotar = N= 60/(2π*r) V*

Were,

N=Velocity Expressed in rpm

V=Velocity of Wind expressed in m/

r = radius expressed in m

$$N = 60/ (2\pi*r) V$$

$$= 666.93 \text{ rpm}$$

- ***Discharge*** **Q=A*V**

Q=0.85*22

Q=18.7m^3/min

- ***Input Power*** **P =1/2*p*A*V^3**

Were,

P=Air density (assume 1.093 kg/m^3)

V=wind velocity in m/s

$$P = 1/2*p*A*V^3$$

$$= 0.5*1.093*0.85*(22)^3$$

$$= 4946.262 \text{ Watts}$$

= 4.94 kWh per day

- ***Gear ratio***

N1/N2 = D2/D1

= 60/600

= 0.095

Therefore N1=0.1N2

❖ **Output power of turbine:**

P = 4946.262*0.1

= 494.62 watts

Table No. 1(Power Generated By VAWT in one day at Different velocity)

Sr. NO	Wind Velocity Generated by Vehicle (m/sec)	Power Output (in watts)	Power Output (in Kwh)	Power Generated In 24hr
1	16.67	215.18	0.215	5.16
2	19.44	341.26	0.341	8.19
3	22.22	509.61	0.509	12.21
4	27.77	9.948	1.0	23.87
5	33.33	1719.94	1.7	41.27

➢ **Total number of VAWT & Total electricity Generated by VAWT**

1) **Average Power Generated by One (1) turbine =** 20kwh per day

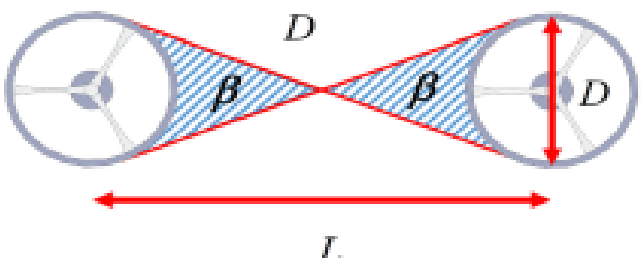
2) **In one day, power generated by the total no of turbine in 20km patch is (4000)**

= 20 * 4000

= 80,000 kWh per day

3) **The cost of electricity generated by the VAWT in One year (cost of 1kw 6Rs)** = 17.52 Cr

4) **Minimum C/C distance required in between 2 turbines = *L= 5*D*=** 5*0.63= 3.15m



5) **Assuming C/C distance in between 2 turbines =** 5m

6) **No of Turbines in 20 KM patch from (Talegaon to Kamshet)**

= Total Distance/5

= 20000/5

= 4000 No

7) **4000 number of turbines required for the 20Km Patch**

8) Cost requirements

No of Turbines*cost of 1 turbine

= 4,000*65,000

= Rs 26 Cr.

(4.2) Calculation of Solar Panel Electricity Generation: -

- ***Formula-***
  - Size Of One Panel (in Sq. m) ×1000
  - That figure × efficiency of one solar panel (percentage as in decimal)
  - That figure × number of sun hours in area each day ÷ 1000
- ***Panel Dimension***

  L=63.5cm

  B=67.0cm

  T=3.4cm

  L×B×T=63.5×67.0×3.4 = 14,465
- ***Divide by 10000 for sq. m of one panel***

  14,465÷10000 = 1.4 sq. m
- ***Efficiency of our panel is 20%***

  1400×0.2 = 280
- ***Area gets 8 hours per day***

  280×8 = 2240 Watts
- ***Divide by 1000 (from watts to kw)***

  2240÷1000 = 2.240 kWh per day
- ***Energy generated by 1 solar panel One month***

  2.24×30=67.2 kWh per month
- **Energy generated by 1 solar panel for One Year**

  2.24×365=817.6 kWh per year

Table No.2 (Electricity generated by one solar panel)

1. Hour of sun light	6 Hours	7 Hours	8 Hours	9Hours	10 hours
2. Electricity generated for one day (kwh per Day)	1.6	1.96	2.24	2.52	2.80
3. Electricity generated for one month (kwh per Month)	48	58.8	67.2	75.6	84
4. Electricity generated for one year (kwh per Year)	584	715.4	817.6	919.8	1022

Table No.3 (Electricity generated by total no of 4000 solar panel in 20km)

1.Time Period Of (sunlight)	5hr	6hr	7hr	8hr	9hr	10hr
2. Solar Energy Stored Per Day (kwh per Day	5,600	4,600	7,840	8,800	10,080	11,200
3. Per Month (kwh per Month)	1,68,000	1,92,000	2,35,200	2,68,800	3,02,400	3,36,000
4. Per Year (kwh per Year	20,44,000	23,36,000	28,61,600	32,70,400	36,79,200	40,88,000

- **Cost of electricity generated by solar panel & total cost required for the installation**

1. **Cost of 1 solar panel**

   5100 * 1 = Rs 5100

2. **Cost of solar panel (4000)**

   5100 * 4000 = Rs 2 Cr

3. **Electricity Generated by 4000 solar panel for one Day (Average 8hours, Cost of 1Kw is 6Rs)**

   8,800 * 6 = Rs 52,800

4. **Electricity Generated by 4000 solar panel for one Year (Average 8hours, Cost of 1Kw is 6Rs)**

   32, 70,200 * 6 = Rs 1.96 Cr

(4.3) Road Rain Water Harvesting Runoff Calculation: -

Considering that the average annual rainfall in Maharashtra is about 350, 500, 700, 1000, 1200 mm respectively, the total annual volume of run-off from a 1 km long Mumbai Pune Expressway, taking run-off coefficient as 20% & 30%,

For Example: -

- ***Formula***

Volume of Runoff = Area × Runoff Coefficient ×Rainfall

Where,

Length of the road (for 1 Km) = 1000 m

Width of the road = 36 m (For both sides of road)

Rainfall = 350 mm

Runoff Coefficient = 20%

- **Volume of runoff = 1000×36× (20÷100) × (350÷1000)**

= 2520 m^3

- **Quantity of water in Liters = 2520 * 1000**

= 25, 20,000 Liters (For 1km)

Table No. 4 (Runoff calculation different mm of precipitation)

Rainfall (in MM)	Runoff Coefficient (in %)	Distance (in m)	Volume (Cubic Meters)	Quantity (in Liters)	Average Quantity (in liters)
350	20%	1000	2520	25,20,000	67,50,000
	30%	1000	3780	37,80,000	
500	20%	1000	3600	36,00,000	
	30%	1000	5400	54,00,000	
700	20%	1000	5040	50,40,000	
	30%	1000	7560	75,60,000	
1000	20%	1000	7200	72,00,000	
	30%	1000	10800	1,08,00,000	
1200	20%	1000	8640	86,40,000	
	30%	1000	12960	1,29,60,000	

Note: - This table presents the approximate volume of water that can be harvested for a given design rainfall, runoff coefficient, and catchment area. Each of the design rainfalls is assumed to have three different runoff coefficients (20 percent, and 30 percent). The table presents simplified estimates and does not rely on measurements of actual runoff, the intensity of individual rainfall events, the shape of the catchment, or losses on the way to the storage point

- **For 20 Km Patch water can be generated can be as follow = Average Quantity of water for 1km×20**

= 67, 50,000×20

= 13, 50, 00,000 Liters Of water in 1 year

= 13.5 Cr Liters of water in 1 year

V - CONCLUSION

Implementing techniques such as vertical axis wind turbines, solar panels, and road rain water collection on national roads or expressways, according to this study of transforming highways into renewable resources. It can improve the rood's efficiency and lead to a future Couse for generating energy, as well as assisting communities suffering from drought and water scarcity.

These wind turbines can operate in both low and high wind conditions, which is advantageous in these places. In comparison to HAWT, it will gather a bigger number of wind towers in a smaller area. It will address the issue of fossil fuel use and will be extremely beneficial to the environment in terms of mitigating global warming. Wind is one of the most adaptable and manageable energy sources available, as the mechanical energy derived directly from the wind can be transferred to various forms of energy quickly and efficiently. The cost of wind power generation has now surpassed diesel power efficiency – VAWT.

Rainwater harvesting, it is argued, is a tool for efficient road drainage and ground-water recharge in order to raise the water table. Implementing road rainwater harvesting for roads would not only collect rainwater but will also result in improved

riding experience, decreased travel time, lower vehicle maintenance costs for road users, lower maintenance costs, longer road life, and so on. . This findings encourages the researcher to focus much more on determining the precise relationship between road drainage and pavement breakdown. Rainwater harvesting is a mechanism for collecting and storing rainfall in tanks and other reservoirs for future use, as it is critical to conserve rainwater so that it does not become scarce. Instead of allowing it to depart the gutter, it can be used for irrigation, gardening, home purposes, and livestock; it can also be used as drinking water. In industrialized countries, collected rainwater serves as a source of supply while also lowering the cost of home water use. Rainwater collecting is used by most countries with unpredictable weather since it is a cost-effective and reliable supply.

Solar energy is efficient since it is free to consume and does not pollute the environment. It is a vast supply of directly usable energy that eventually generates other energy resources. Solar power is the conversion of solar energy into thermal or electrical energy. Solar energy is the most environmentally friendly and abundant renewable energy source. Solar energy has the potential to supply all of the energy humans will ever require. We have the technology to gather this energy, but we need to invest more money and continue to develop and perfect it. As a result, we believe that solar energy is the energy of the future, capable of meeting all of our energy needs while also eradicating pollution caused by other sources of energy.

VI - FUTURE SCOPE

- Engineers may put the turbines closer together because of the vertical design. Because they don't have to be spaced far apart, a wind farm can be built on a smaller piece of land. The close proximity of horizontal wind turbines can cause turbulence and wind speed drops, affecting the production of surrounding units.
- Wind energy may be generated from relatively tiny winds by developing effective alternators and dynamos
- After hydroelectric plants and horizontal axis wind turbines, vertical wind turbines could become the third largest natural electricity producing element
- Solar energy will be available as long as the sun exists, therefore we will have access to it for at least 5 billion years after the sun dies, according to scientists.
- Solar energy systems don't require much care; all they need is to be kept relatively clean, which can be accomplished by cleaning them a couple of times per year. You can always rely on expert cleaning providers if you're in doubt. The cost of solar panel maintenance is less than 2% of the overall cost of the panels.
- Among the many advantages of solar panels, the most essential is that it is a fully renewable energy source. It can be used in any part of the world and is available at all times. Unlike some other energy sources, we cannot run out of solar energy.
- The rainwater that flows off in the urban areas can be collected and stored to recharge the groundwater level or the aquifer bed, instead of letting the water flow into the drains.
- Instead of letting rainwater flow into drains, it can be collected and held to recharge the groundwater level or the aquifer bed.
- The water collected from road surface runoff can be treated to remove pollutants and stored and reused for daily use and agriculture.

VII - ACKNOWLEDGMENT

I wish to express my deep sense of gratitude towards my guide **Prof. A. K. Kadu (Civil Engineering Department)** for giving me an opportunity to work on this topic. They have always encouraged me with new ideas & helped me to develop interest in this field. There valuable inputs, precise guidance, unremitting encouragement & vigilant supervision were instrumental in carrying out this topic.

I would also like to thank **Dr. C. M. Sedani (Principal, PVPIT)**, **Dr. R. R. Sorate (H.O.D. Civil Engineering Department, PVPIT)** & all Civil Engineering faculties for their kind advice & support. I also thankful to my parents for their moral support, motivation & encouragement. Thank you.

VIII - REFERANCES

[1] Md Aminul Hassan, Dr C B Vijaya Vittala Dept "*Analysis of Highway Wind Energy Potential"* international Journal of Engineering Research & Technology (IJERT) SSN: 2278-0181, Vol. 3 Issue 4, April – 2014.

[2] Mr. Mukesh Kumar Sharma *"Assesment of Wind Energy Potential from Highways"* (IJERT) ISSN: 2278-0181 Vol. 1 Issue 8, October – 2012.

[3] Md. Sultan Mahmud, Md. Rabiul Hasan Abir, S.M.G Mostafa, d. Shoyab Abdullah Chy *"Design and Analysis of a Vertical Axis Wind Turbine for Highway Application in Bangladesh"* Jour of Advs. Research in Dynamical & Control Systems, Vol. 12, 07-Special Issue, 2020.

[4] Saurabh Arun Kulkarni1 & Prof. M.R. Birajdar2 *"Vertical Axis Wind Turbine for Highway Application Imperial Journal of Interdisciplinary Research (IJIR)* Vol-2, Issue-10, and 2016 ISSN: 2454-1362.

[5] Vinit.V. Bidi1, Devendrappa .M. K, Chandan. S. P 3, Arun.J. P 4, Maruthi.G. *V "Highway Power Generation using Low-Cost Vertical Axis Wind Turbine"* IEJSC Volume 7 Issue No.5 2017 IJESC.

[6] Xiaochun Qin, Yi Shen, and Shegang Shao *"The Application Study in Solar Energy Technology for Highway Service Area: A Case Study of West Lushan Highway Low-Carbon Service Area in China"* Hindawi Publishing Corporation International Journal of Photo energy Volume 2015, Article ID 703603, 8 pages.

[7] Kiran Pal Kour, Loveneesh Talwar *"Go Green with Solar Roadways: - A Review"* International Journal of Innovative Research in Science, Engineering and Technology IJIRSET Vol. 8, Issue 10, October 2019.

[8] MD. Atiar Ali (EEE, UITS) "Solar system (PV) calculation and design. *"Green Roads for Water Guidelines for Road Infrastructure in Support of Water Management and Climate Resilience"* © 2021 International Bank for Reconstruction and Development / The World Bank 1818 H Street NW, Washington, DC 20433.

[9] Frank van Steenbergen, Fatima Arroyo-Arroyo, Kulwinder Rao, Taye Alemayehu Hulluka, Kifle Woldearegay, and Anastasia Deligianni"

[10] Frank van Steenbergen, Kifle Woldearegay, Marta Agujetas Perez, Kebede Manjur and Mohammed Abdullah Al-Abyadh *"Roads: Instruments for Rainwater Harvesting, Food Security and Climate Resilience in Arid and Semi-arid Areas"*

[11] Pretty, J., Toulmin, C., Williams, S. (2011). Sustainable intensification in African agriculture. International journal of agricultural sustainability, 9(1), 5–24

[12] GOVERNMENTOF INDIA MINISTRY OF ROAD TRANSPORT & HIGHWAYS (S&R (P&B) Section) Transport Bhawan, 01, Parliament Street, New Delhi-110 001 Dated: 3 September, 2019

[13] Dr.Y.Ramalinga Reddy, Anil Kumar K.S "ESTIMATION OF ROAD SURFACE DRAINAGE WATER AND USE OF SAME DRAINAGE WATER FOR THE ECOLOGY DEVELOPMENT A CASE STUDY: NH44 HEBBEL TO INTERNATIONAL AIRPORT DEVANAHALLI THROUGH FLYOVER" (IJCIET) Volume 8, Issue 9, September 2017.