Renewable Energy Based Wireless Power Transmission to Electric Vehicles for Fuel Consumption

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Abstract— In modern days, fuel energy has become a crisis because they have a concentrated storage. So, now renewable energy plant is needed to cover more sectors not only power but also in running vehicles. All transport system will be run by this available energy. Electricity will be transformed into microwave beam and then charge the vehicle and it will help to retain our environment clean without pollution as well as human life will also become healthful. This wireless power transfer system may reduce the demand of fossil fuels .electric vehicle (EV) and plug in hybrid EV are the sample of this system. They capture microwave beam as a replacement of fuel.

Index Terms – Renewable energy plant, Phased array antenna, Microwave beam, Rectenna, Electric hybrid vehicle, Fuel consumption.

1 INTRODUCTION

During the last few decades, the fuel based transport system polluted environment. So two electric vehicle (EV) Battery based electric vehicles (BEV) and Plug in hybrid vehicle (PHEV) is best idea for fuel consumption and zero emission. This sort of vehicles differs from fuel based system and it will run by renewable energy through wireless power transmission system via microwave beam. Electricity may store using battery, flywheel and super-capacitor **[4]**. Wireless power transmission via microwave advanced from WC Brown invented microwave powered helicopter. The phased array antenna transmit microwave beam and this will be collected by rectenna used in EV. In this paper EV will charged by microwave beam for fuel reduction and lessen CO_2 emission.

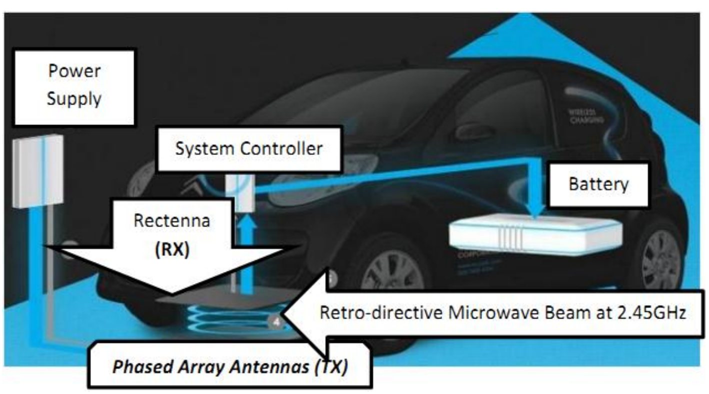

Fig 1: Concept of wireless power transmission in electric vehicle

2 POWERS GENERATED FROM RENEWABLE ENERGY SOUECES

Renewable energy is the most upcoming technology for produceing huge amount of electrical power. It lessens the need of fuel energy based power production and also make our environment clean. Many developed countries use this source for fill up their demand.

2.1 Renewable energy plant explanation

World top renewable energy plants are compressed natural gas , bio-mass ,geo-thermal power , radiant energy; hydroelectricity plant , wind power, solar power , wave power ,tidal power. All renewable energy plant is most efficient for next generation power crisis. These sources of energy provide an alternative cleaner source of energy helping to negate the effects of certain forms of pollution. About 16% of global final energy consumption comes from renewable sources, with 10% coming from traditional biomass and 3.4% from hydroelectricity. Wind power is growing at the rate of 30% annually with a worldwide installed capacity 198 GW in 2010 widely use in Europe Asia and United States. World largest Geo-thermal plant has installed in the Geysers in California with a rated capacity 750MW. Brazil has one of the largest renewable energy programs involving production of ethanol fuel from sugarcane and ethanol provides 18% of the country's automotive fuel. Modern wind turbine turbines range from around 600KW-5MW. There 439 nuclear power plant in 31 countries

2.2 Supporting power plant in fuel station

There need some supporting station by road side from where EV or HEV can easily charge up. And this supporting station may have solar plant , Bio gas plant, wind energy plant for supplying electricity. Some are explain below:

2.2.1 Solar energy plant

Solar energy more useful renewable energy which overcome our power crisis. Upcoming day our natural resource will vanish and than renewable energy will survive our planet. Earth based solar plant have less efficiency approximately 25-26% but it can help as a hand of hydroelectric plant, gas-turbine plant and so on fuel based plant. There two method of converting sunlight beam to electricity: Photovoltaic conversion and solar dynamic conversion. Photovoltaic conversion uses semiconductor Si or GaAlAs cells to directily convert photon into electrical via a quantum mechanism. Thevehicle system can charged up by solar energy via microwave beam.

2.2.2 Solar cell fabrication and efficiency

Concentrator photovoltaic system more efficient because it has inexpensive cell such as plastic lenses, increases the density of sun light, made of small individual cells. Flat plate solar cell less weight and useful to use in all sector.

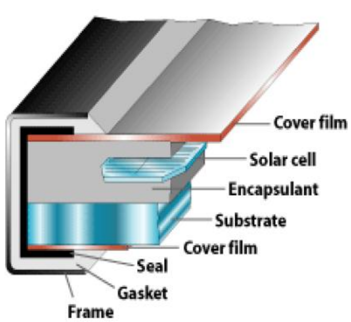

Fig 2 : Flat-plate Solar Cell sample

Concentrator PV cell has large tracking power of solar cell, potential for solar cell efficiencies 40%, no moving part, no intervening heat transfer surface, near-ambient temperature operation, no thermal mass, fast response, reduction cost**[9].** Solar cell based on 3J technology much better constructed which efficiency up to 40% and manufacturer is trying to produce at least 37% efficient cell.

Table1: Solar cell efficiencies

Cell type	Demonstrated efficiency at laboratory devices	Efficiency at production devices
Triple junction concentrator cells(GaInP/GaIn As/Ge)	40.7%	37%
Single crystal GaAs	24.7%	22%
Multi-crystalline Si	20.3%	18.5%
Thin film CdTe on glass	16.5%	10.5%

2.2.3 Bio-gas power plant

Bio –gas plant may be created in household system for charging vehicles. From the wastage of our daily necessaries it may produce methane gas and using this we can heated water and then using heated water pressure turbine will help to operate generator. In china there is bio-gas plant for generating power in home.

2.3 Renewable energy plant in central vehicle station

For charging vehicles there should be a renewable energy plant which needs to establish in vehicle station. It will charge up via microwave beam in Electric vehicle (EV) or Hybrid electric vehicle(HEV).

2.4 Power stored system

Power from all source gathered by a national grid and supply it where it need. From this huge supplied power all transport system will run in upcoming days. This power will be supplied to vehicle station from where vehicle get charge via microwave beam or in plug in three phase system.

3 MICROWAVE ENERGY CONVERSIONS TO DC POWER

3.1 Microwave device explanation

Microwave oscillator and amplifier use for produce high power microwave beam using low power microwave beam. It's help to produce more powered beam width.

3.1.1 Microwave oscillator

3.1.1.1 Travelling wave tubes (TWT) power supply:

TWT has three major parts the anode the, helix (coupled cavity) grounded structure and the collector. In some medium power TWTs the use of separate collector is optional (operation with either a depressed or a grounded collector) but the high power TWTs are all operated with a depressed collector. The switching on of a helix TWT requires either a fast rise time of the helix voltage or a means of preventing beam current until the voltages are at operating values. One method is to use a switch which allows the anode to be clamped to cathode when the collector and helix voltages are applied ("off " position) and then afterwards the anode voltage, derived from the helix supply, is applied ("on" position). Another means is to use a separate power supply for the anode providing a voltage which delayed with respect to the helix voltage

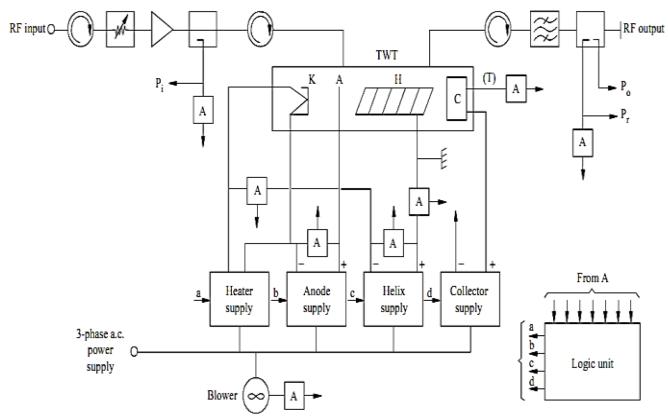

Figure 3 : Block diagram of TWT HPA (500-700W)

This TWT able to generate 500W with some typical values:

- Helix voltage: 10kV, Helix current to be limited to 15mA.
- Anode voltage: 6kV, Current 1mA
- Collector voltage : 6kV, current 400mA
- Heater voltage should be regulated within 0.1V

3.1.1.2 Klystron power supply:

Klystrons have a single high voltage for the beam is between the cathode and the collector. Unlike the helix TWT, the beam voltage can be run up slowly. The klystron amplifier is sensitive to the beam power supply variations. In order to ensure high gain stability, it is necessary either to regulate the beam voltage or to use an automatic level control which reduces the gain variations caused by fluctuations of beam voltage. Typical values for a 3kW klystron have 8.5 kV for the beam voltage and 1A for the collector current.

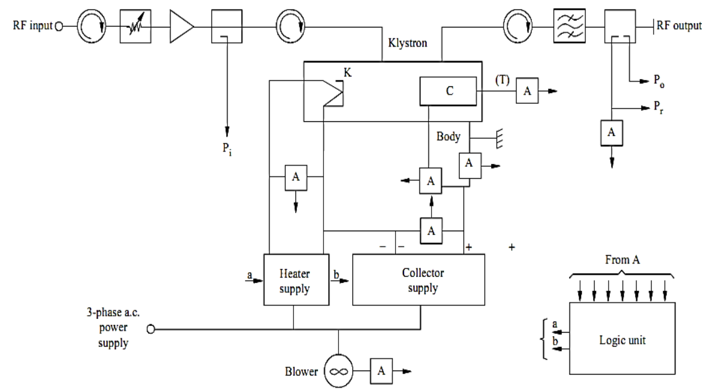

Figure 4: Block diagram of a Klystron HPA (1-3kW)

3.1.2 Microwave amplifier

Microwave amplifier may use for application ranging from testing passive elements, such as antennas, to active device as limiter diodes or MMIC based power amplifier. It use for testing system losses to a radiating element and it may be found as a system requirement to radiate a device-under-test(DUT) with an intense EM field for EMI/EMC applications. Many tubes (Travelling Wave Tube)and solid state device use for designing amplifier .

3.2 Phased array antenna (transmitting beam)

Phased array transmitting antenna radiates microwave beam to electric hybrid car's rectenna. Microwave beam need to be retro-directive and a PLL-Heterodyne type retro-directive system which generate microwave beam at 3.85GHz and 5.78GHz**[7].**Some phase locked loop (PLL) based phased array antenna are describing below.

3.2.1 Phased Locked Loop (PLL) Magnetron

Phased Controlled Magnetron (PCM) has a circulator for injection locking and it causes over 10% loss of microwave in fig. 6. But in fig. 5 PLL magnetron is feedback for higher stabilize microwave beam than PCM because they have no injection locking for stabilizing the frequency of magnetron. The frequency response of a high voltage source the PCM and PLL magnetron use only 120Hz. Both phase and frequency controlled by this two type magnetron **[8].**

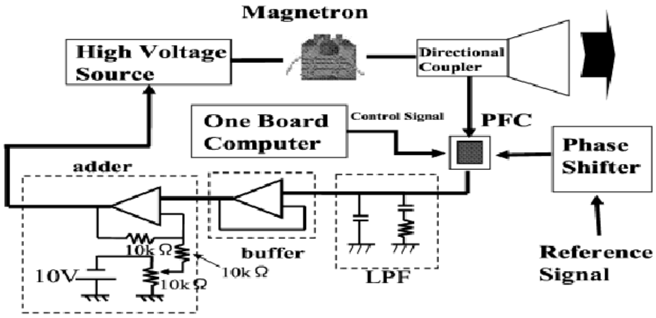

Fig 5: Diagram of PLL magnetron.

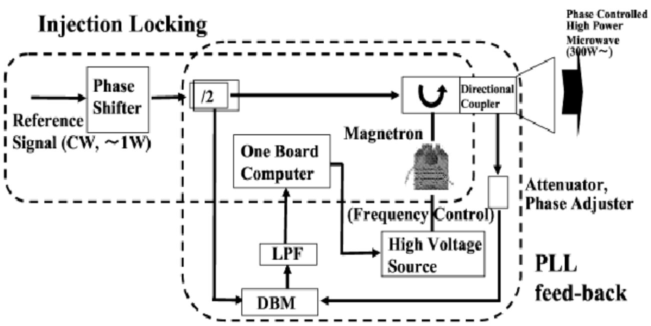

Fig 6 : Block diagram Phase Controlled Magnetron

3.2.2 Compact Microwave Energy Transmitter

Lightweight compact microwave transmitter (COMET) has higher efficiency of DC-RF conversion to control microwave beam. COMET is developed on PCM technique ,it is designed on 5.8GHz Continuous Wave Magnetron having 310ф×99mm transmitting antenna weight only 7Kg. COMET includes DC/DC converter, a control circuit of a PCM , a heat radiation circuit, a waveguide and antenna. Approximately 32% of a total weight of the COMET is a heat radiation circuit and 25% is DC/DC converter **[8].**

4 RECTENNA IN HYBRID VEHICLES

Rectenna is defined as rectifying antenna. A rectenna is capable of receiving microwave energy and converting the received microwave power back to usable low or DC power and stored in vehicle battery. A basic rectenna consists of an antenna, a dipole rectifier and a dc bypass filter. In hybrid vehicles an aperture coupled micro-strip patch antenna (ACMPA) is suitable for capture power beam because they have more advantages and better prospects like they are lighter in weigth, low volume, low cost, low profile, smaller in dimention and ease of fabrication and conformity. It has also capability of high harmonic rejection. The rectenna with integrated circular sector antenna can eliminate the need of low pass filter (LPF) placed between the antenna and the diode as well as produce higher output power, with maximum efficiency **[2]**.

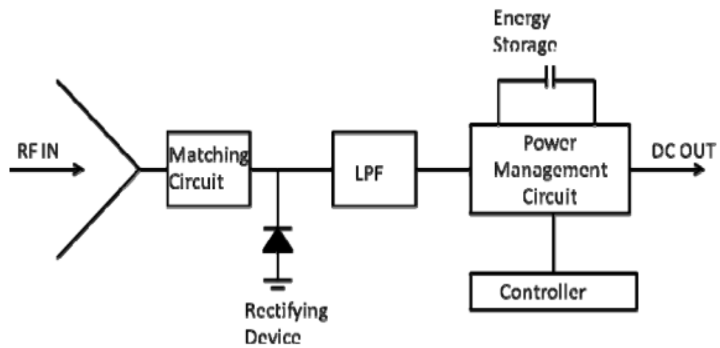

Fig 7: Schematic of rectenna associated with power management circuit in hybrid vehicle

The RF power ***Prf*** received by the antenna is a function of the incident power density(**S**), effective area of the antenna (**A**eff), incident angle and frequency. The DC power calculated from RF power, convertion efficiency and the DC load impedence (**Z**dc).The fluctuation in the incident power density will alter the conversion efficiency and subsequently the outout***Pdc*** power at rectenna at eqn(2):

$$\mathbf{Prf} = \frac{1}{\mathbf{fhigh-flow}}\int_{\mathbf{f\ low}}^{\mathbf{f\ high}}\int_{0}^{4\pi}\mathbf{S}(\theta,\varphi,\mathbf{f},\mathbf{t})\mathbf{Aeff}(\theta,\varphi,\mathbf{f})\,\mathbf{d}\Omega\,\mathbf{df} \qquad (1)$$

$$\mathbf{Pdc} = \mathbf{Prf}(\mathbf{fi},\mathbf{t})\,\eta(\mathbf{Prf}(\mathbf{fi},\mathbf{t}),\rho,\mathbf{Zdc}) \qquad (2)$$

4.1 Rectenna specification

Rectenna is capable to produce high conversion efficiencies (~90%). Components of microwave beam transmission have traditionally been focused on 2.45GHz but recently it moving up to 5.8GHz, it has smaller antenna aperture area than 2.45GHz one. Both two system have low atmospheric loss, cheap components availability. for development of rectenna some points need to be consider.

4.1.1 Microwave power achievement

High frequency microwave beam passes through rectifying diode and convert it to DC energy. The micro-strip antenna has the characteristics of light, easy and small size manufacturing. However it has demerit also due to relatively narrow bandwidth, restricted incident power and low gains. Though micro-trip patch antenna is adopted due to its big size and no polarization characteristics. A HSMS 8202 Schottky diode is chosen for rectifying circuit. The rectenna shows the maximum gain as 6.2dBi at the frequency of 5.8GHz with PTFI (Teflon) board of 10 dielectric constant and 1.6 mm thick. A broadband capacitor C08BLBB1X5UX is chosen as the DC pass filter **[1].**

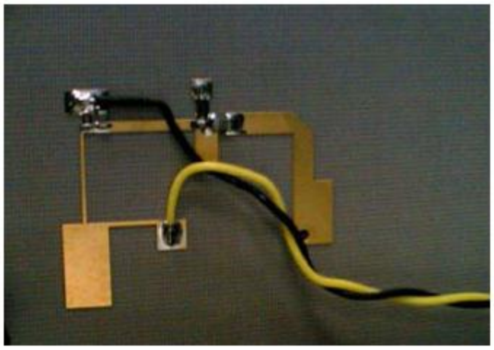

Fig 8: The manufactured of rectifying circuit.

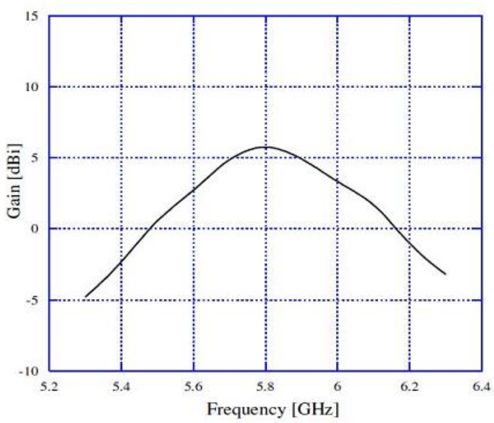

Fig 9: Measured gain of manufacturing antenna at 5.8 GHz frequency.

4.1.2 Harmonic rejection system development

A antenna having the property of harmonic rejection eliminates the requirement of LPF between the antenna and diode. In this way additional insertion loss at the fundamental frequency associated with the LPF in a conventional system can be eliminated to produce higher efficiency. A. Georgiadis, G. Andia and A. Collado proposed a methodology to design a rectenna utilizing reciprocity theory and combining electromagnetics simulation and harmonic balance. They designed a 2.45GHz rectenna based on a square aperture-coupled patch antenna with dual linear polarization and found that by etching a cross shaped slot on the patch surface, the size of patch reduced by 32.5%. J.Y Park , S M Han and T. Itot proposed a rectenna designed with a microstrip harmonic rejection antenna at 2.45GHz which having maximum efficiency 77.8% using 150 ohm load resistor**[1]**

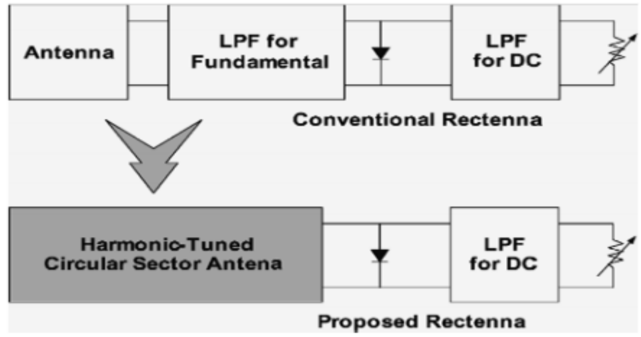

Fig 10: Block diagram of conventional and proposed rectenna

4.1.3 Circularly polarized

The circular polarization (CP) has more fade resistant than linear polarization and low polarization loss between transmitting and receiving antennas. The combination of CP property and and harmonic rejection would bring the advantages of low polarization loss, conversion efficiency enhancement and simpler design. T.C Yo et al. proposed a compact CP which use double rectifier gives 78% of RF to DC conversion efficiency at 16.5mW/cm² incident power. The doubler layer configuration and circular slot make the rectenna much small(12% size reduction) and compact(2.4mm in thickness). M.Ali, G. Yang an R. Dougal proposed a CP rectenna operating 5.5GHz in 2006**[1]** which reduce harmonic emission with the help of integrated BRF.

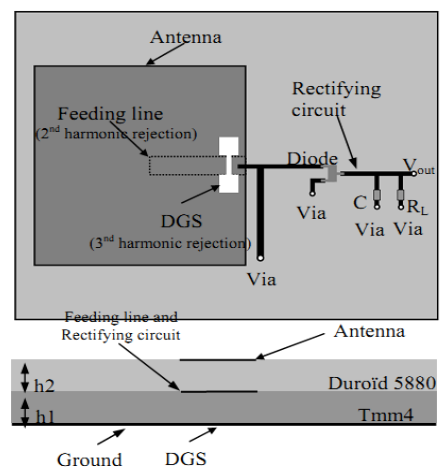

Fig 11: Proposed micro-strip antenna for harmonic rejection

The conversion efficiency of the CP rectenna in fig. 11 is given by

$$\eta = \frac{\frac{Vd^2}{Rl}}{PtGtGT\left(\frac{\lambda o}{4\pi r}\right)^2 Lpol} \qquad (3)$$

Pt= Transmit power, Gt=Gain of transmitting antenna,GT=Gain of rectenna, Lpol=Polarization loss factor, Vd=Output voltage.

4.1.4 High efficiency measurement

The Strassner and K. Chong proposed a new CP high efficiency rectenna array designed in a coplanar stripline circuit. The single element antenna uses a CPS band reject filter to suppress the reradiated harmonic by more than 19dB and achieve 81% RF to DC conversion efficiency at 5.71GHz. However in 2002 Y.H Suh and K. Chang proposed a dual frequency printed dipole rectenna suitable for wireless power transmission at 2.45 and 5.8GHz(ISM bands) and conversion efficiency more than 77%. J.O Mcspadden, L.Fan and K. Chang designed a high efficient rectenna element in which they use a silicon Schottky barrier mixer diode with a low breakdown voltage as the rectifying device and its efficiency 82%**[1].**

4.1.5 Duel frequency

With the usage of multiple frequency bands in wireless communication systems some dual frequency rectenna have been developed. Y.J Ren, M.F Farooqui and K. Chang proposed a novel dual frequency antenna operating at 2.45GHz and 5.8GHz. This rectenna consists of two compact ring antennas, a hairpin LPF and a rectifying circuit. It sipress 2nd and 3rd harmonics and conversiob efficiency 65%

4.1.6 ISM frequency at 5.8 GHz

Y.J .Ren and K.Chong proposed two new CP retro-directive rectenna array having a 2×2 and 4×4 arrays and they used a proximity coupled microstrip ring antenna which can block signals upto 3rd harmonics. It has CP gain 5.89dB and conversion efficiency 73.3% . This technique is very suitable for WPT with a high gain, but narrow beam width transmitting antenna. A truncated dual patch antenna has a CP gain of 6.38dB and it use coplanar stripline band pass filter to suppress signal genettated from the diode by over 32dB which block 2nd and 3rd harmonics. Its efficiency for dual diode rectenna 76%**[1].**

5 SAMPLES OF PRACTICAL TRANSMITTING AND RECEIVING ANTENNA

A simple model of phased array transmitting four horn antennas is connected to power amplifier and whole line connected with a divider. Here microwave oscillator will generate microwave beam and antenna will provide beam to electric vehicles.

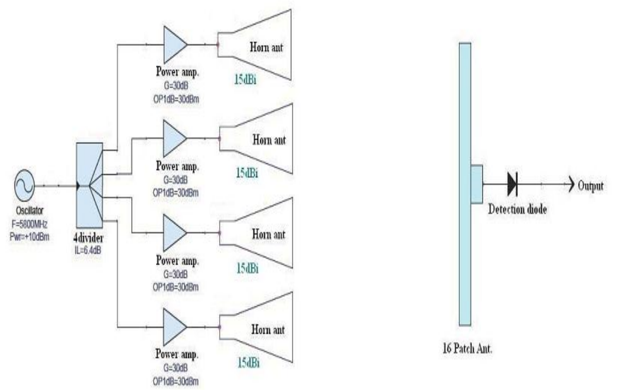

Fig 12: Experimental configuration of wireless power transmission to electric vehicle

The experimental configuration of the wireless power transmission for electric vehicles is provided by a field effect transistor (FET) oscillator and divided into four elements using a power divider. Four FET amplifiers with the output power 1 watt each are used to have totally 4 watts output power. Each microwave is guided to an antenna through a co-axial cable. In this experiment a horn antenna whose exit size is 112mm× 85mm, is used and four antennas are arranged as shown in figure 12.

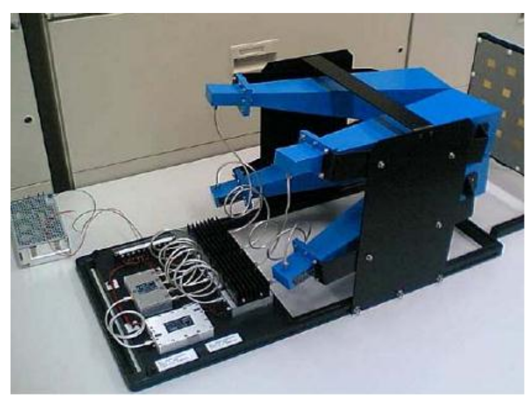

Fig 13: Transmitter for wireless power transmission

Each horn antenna gain 16dBi. The distance between the horn antenna and the center of rectenna array for measurement are 200mm, 250mm, 300mm, 350mm and 400mm. Rectenna is designed eith the PTFT board of 10 dielectric constant and 1.6,, thick. The 4×4 rectenna array consists of 19mm×15mm as shown in Fig.13. The patch antennas are in front and rectifying circuits are in back of antenna. We adopted 5.8GHz rectenna since the frequency of 5.8GHz is ISM band. In this case, no license is necessary to experimentalize the wireless power transmission for electric vehicles. The 4×4 rectenna array is used and the load resistance is chosen as 50 ohm. The RF to DC efficiency is defined as

$$\eta = \frac{\mathbf{Pdc}}{\mathbf{Pr}} \times \mathbf{100\%} \quad (4)$$

Where Pdc is the DC output power and Pr is the power received by rectenna that is calculated by using the Friss transmission equation**[7].** By changing the distance between the transmitting antenna and rectenna array, the efficiencies for different power densities can be determined. The power density Pd is given by

$$Pd = \frac{PtGt}{4\pi D^2} \quad (5)$$

Where Pt is the transmitting power, Gt is the horn antenna gain and D is the distance between the horn antenna and the center of the rectenna array.

For a small transmission distance, the rectenna does not work as well as like long distance like 400mm. one possible reason is that incident power density is not uniform for a large array. Therefore not all of the rectenna elements have the same output voltage to their different positions. From this reason transmitter beamforming is necessary to increase the conversion efficiency. When we increase the transmission power, the transmission distance can be increased. In this case, the incident power density would be uniform. Therefore the conversion efficiency of rectenna array would be improved. The experimental result is given below.

Table 2 : Experimental result of efficiency for distance.

Distance (mm)	Conversion efficiency (%)
200	49
250	57
300	61
350	69
400	75

6 DC POWER STORED IN VEHICLES

Transformation of microwave beam into DC power and it stored in Battery. The hybridization of a chemical battery with an ultra-capacitor can overcome problems of low specific power of electrochemical batteries and low specific energy of ultra-capacitors, basically the hybridization energy storage consists of two basic storages: high specific energy and high specific power

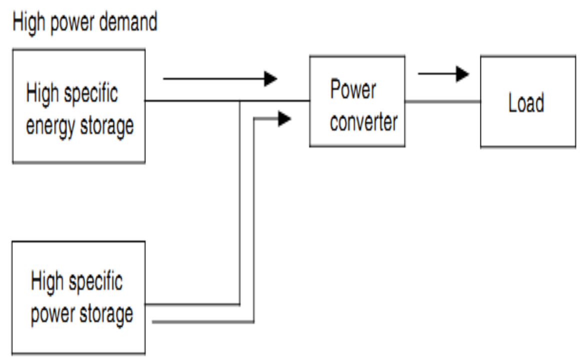

Fig 14: Concepts of hybrid energy storage operation

There's also a concept of ultrahigh-speed flywheels appears to be a feasible means for fulfilling the energy storage requirements for EV and HEV applications, namely high specific energy, high specific power , long cycle life, high energy efficiency , quick recharge, maintenances free characteristics, cost effectiveness and environmental friendliness.

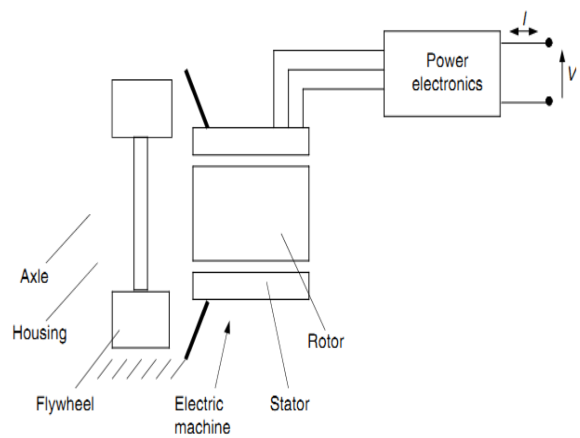

Fig 15: A basic structure of typical flywheel system (mechanical battery)

7 ENERGY STORAGES

7.1 Battery Technologies

In this modern age, unbelievable progress has been achieved on battery technologies for EV and PHEV. The batteries which are mainly used to operate EV, HEV & PHEV are consist of the lead-acid battery, nickel-based batteries such as nickel/iron, nickel/cadmium, and nickel–metal hydride batteries, and lithium-based batteries such as lithium polymer and lithium-ion batteries **[10].**Among these available technologies, two major categories of battery chemistries can meet the PHEV & PEV goals: Nickel-Metal Hydride (NiMH) and Lithium-Ion (Li-Ion) [2].

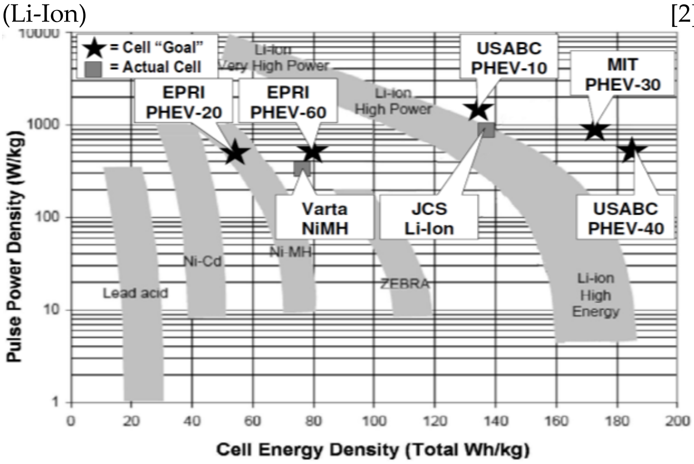

Fig.16. Battery Potential and PHEV —Goals (Ragone Plots)

Here, Fig.16 **[11]** represents of Ragone plots for comparing various types of battery technologies. Actually it was a report of Axsen*et al*.**[12]** to establish the technical achievement of the latest battery technology in PHEV. The outcome of this report refers to three different sources:1) the US Advanced Battery Consortium (USABC) by Pesaran*et al.* **[13];** 2) the Sloan Automotive Laboratory at MIT by Kromer*et al.* **[14];** 3) the Electric Power Research Institute (EPRI) by Duvall [6].According to USABC goals **[13],** the power capacity target of PHEV-10 is 830W/Kg & PHEV-40 is 380W/Kg. Also the corresponding energy density is 100Wh/Kg & 14Wh/Kg. And the costs are $200-$300 per Kwh **[11].**Though EPRI's goals for PHEV-20 can be gained by using NiMH technology, while the performance goals of USABC & MIT are way beyond current Li-Ion technology**[11].**

Table 3: NiMH vs. Li-Ion Battery Technologies

Properties of battery	NiMH	Li-Ion
Power Density (W/kg)	250	540
Energy Density (Wh/kg)	57	94
Cycle Life (cycles)	>3000	>3200
Energy Efficiency (%)	70	>95

From Table 3 **[16, 17]**, it is quite sure that lithium-ion batteries are more reliable & efficient than other electrochemical approaches when optimised for both power & energy density. But longevity and safety are still the shortcomings of Li-Ion battery **[11].**

8 COMPARISON OF ENERGY EFFICIENCY

At this time, batteries are being used as the alternative energy of fossil fuels. From Fig.17 **[17],** it is clear that the net calorific values of diesel and gasoline exceed hydrogen & Li-ion. But we know that the conversion efficiency denotes the thermal output. In this case, Li-ion technology is greater than all others. But there needs further development to ensure the ultimate success of electric vehicle.

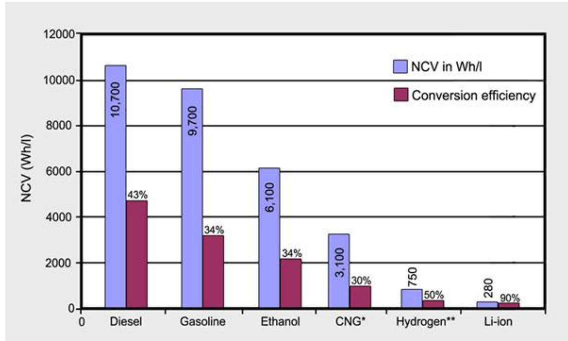

Fig.17. Net calorific values of fuels with conversion efficiencies

9 GLOBAL IMPACT

The automotive industry plays an essential role in building modern developed society. But the large number of automobiles has caused & still causing serious problems for the environment & human life. On the other hand, electric vehicles i.e. PHEVs able to increase a portion of vehicle miles to potentially low-carbon electricity sources & EVs promise to fully change transportation into the electricity system **[18].**

9.1 Fuel Storage

The vast part of our transportation system depends on the liquid fossil fuels originating from petroleum sources. As we know that global petroleum resources are finite.

Table 4 : Proved Petroleum Reserves in 2000

Region	Proved reserves in 2000 in Billions Tons	R/P ratio
North America	8.5	13.8
South and Central America	13.6	39.1
Europe	2.5	7.7
Africa	10.0	26.8
Middle East	92.5	83.2
Former USSR	9.0	22.7 (Asia)
Pacific	6.0	15.6
World	142.1	39.9

In the Data Table-4, the proved reserves are given in the British Petroleum 2001 estimate **[20],** are given in billion tons. The R/P ratio refers the number of years that the reserves would last with respect to the current production rate. Another survey informs that global oil demand increased by 11% from 2005-2010 & it will be increased another 25% by 2030 **[21].** So, in this condition BEVs & PHEVs can be a great opportunity to reduce the fuel consumption.

9.2 Fuel Cost

It is true that the primary cost of ICE vehicles remains lower than the cost of PHEV & BEV. But the fuel of EV i.e. electricity prices are less volatile than oil or gasoline prices. Since 1983, the avg. retail price of electricity in U.S.A has risen less than 2% per year **[22].** In that time, oil prices have increased by more than 5% per **[21].**

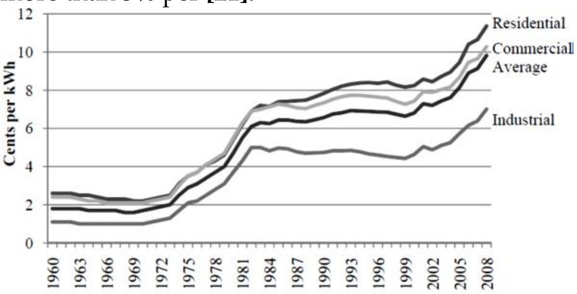

Fig.18. Average Price of Electricity 1960-2008

9.3 Environmental Effect

The conventional vehicles which mainly rely on hydrocarbon fuels cause air pollution. In the combustion of fossil fuels, there not only produces CO_2 but also NO_x, CO, unburned hydrocarbons & other pollutants. Global warming is also a result of the presence of CO_2 & other gases like methane, in the atmosphere. Keeping the consequence of these effects, earth temperature results major ecological damages & natural disasters.

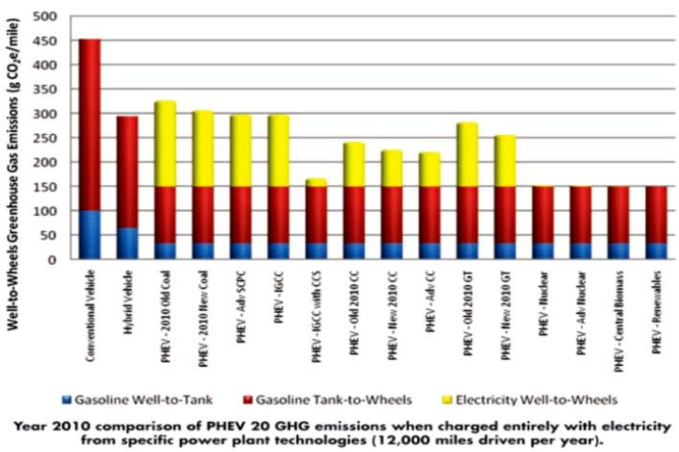

Fig.19. 12,000 Mile/Yr. PHEV 20 GHG Emissions by Fuel/Technology **[23]**

From Fig.19 we can reach a decision that HEVs, PHEVs produce comparatively less CO_2 than CVs. As coal fuels around 45% of electricity generation in the U.S. so we can say that CO_2 is also produced to supply electricity to EVs **[21].** But it needs to ensure that the emission of EVs is less than CVs. To overcome this problem, renewable energy based charging station can be a significant solution.

9.4 Future of Electrified Vehicles

The Energy Technology Perspectives (ETP) 2010 BLUE Map scenario fixed a target to reduce 50% CO_2 by 2050. And this goal can be achieved in part by accomplishing an annual sale of approximately 50 million light-duty EVs & 50 million PHEVs per year by 2050.**[24]**

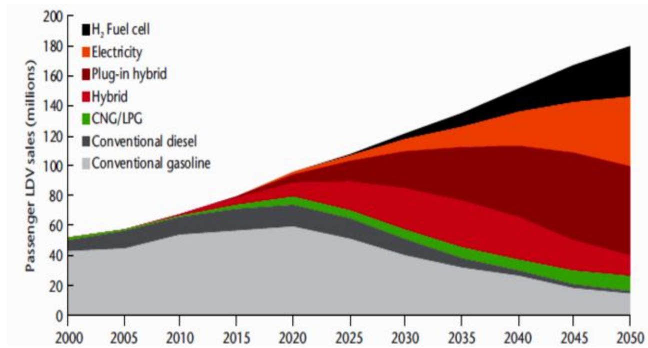

Fig.20. Annual light-duty vehicle sales by technology type, BLUE Map scenario

Here Fig.20 indicates the roadmap of rapid light-duty vehicle technology evolution over time.
Some potential locations for renewable energy based Re-charging stations are Public Administration, Train station, Shopping Center, Park and Sports Arena.

Fig 21 : Sample model of EV charging station

10 FUTURE WORKS

We are so much enthusiastic to upgrade our whole transport system via wireless power transmission. We would like to initiate the following steps such as

1. By developing electrified roads and highway to charge EV vehicles.
2. By transforming a significant number of fuel stations into renewable energy (Solar , Wind, Biogas) based recharging station.
3. Developing highly efficient phased array transmitting antenna and rectenna circuit in vehicles in order to capture microwave beam.
4. Develop the power of baterry to ensure safe and quick charging for EV and PHEV

11 CONCLUSIONS

In this paper we try to develop a renewable energy based Re-charging station for the electrified vehicles. The another point of our study is to build whole transport system on the basis of microwave beam via wireless power transmission. This may keep our environment green and protect it from emission of CO_2 and also to reduce GHG gas.

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