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Wireless electricity (Power) transmission using solar based power satellite technology

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Abstract. In the near future due to extensive use of energy, limited supply of resources and the pollution in environment from present resources e.g. (wood, coal, fossil fuel) etc, alternative sources of energy and new ways to generate energy which are efficient, cost effective and produce minimum losses are of great concern. Wireless electricity (Power) transmission (WET) has become a focal point as research point of view and nowadays lies at top 10 future hot burning technologies that are under research these days. In this paper, we present the concept of transmitting power wirelessly to reduce transmission and distribution losses. The wired distribution losses are 70 - 75% efficient. We cannot imagine the world without electric power which is efficient, cost effective and produce minimum losses is of great concern. .This paper tells us the benefits of using WET technology specially by using Solar based Power satellites (SBPS) and also focuses that how we make electric system cost effective, optimized and well organized. Moreover, attempts are made to highlight future issues so as to index some emerging solutions.

1. Introduction

The present electricity generation system is not very efficient in terms of energy transfer. About 20 to 30% energy is lost during the distribution of the electricity. Therefore the scientists are working on the projects to improve the ultimate electricity supply. Scientists are looking for alternate and efficient technologies to provide 100% electricity transfer. The change and development in the various fields have brought more client satisfaction and output. Therefore the wireless transmission of electricity is also on move [1].

In 1864, James C. Maxwell predicted the existence of radio waves by means of mathematical model. In 1884, John H. Poynting realized that the Poynting vector would play an important role in quantifying the electromagnetic energy. The prediction and evidence of the radio wave in the end of 19th century was start of the wireless power transmission. During the same period of Marchese G. Marconi and Reginald Fessenden who are pioneers of communication via radio waves. Nikola Tesla is known as the father of wireless transmission. The most famous wireless technology known as Wardenclyffe tower also known as the Tesla tower [1 - 3] is the first was designed merely for wireless transmission of electricity. He made electric coil which was a 3 feet diameter ball at its top. He fed

300 kW power to tesla coil resonated at 150 kHz. The RF potential at the top sphere reached 100 MV. Unfortunately he failed due to diffusion in all directions [1, 3].

2. Wireless Electricity Transmission (WET) technology

Wireless power transmission [4, 5] is a process that takes place in any type of system in which electrical current is conveyed from a power source to an electrical load. What makes this process unique is that there is no usage of any type of wiring to connect the system to a source of power.

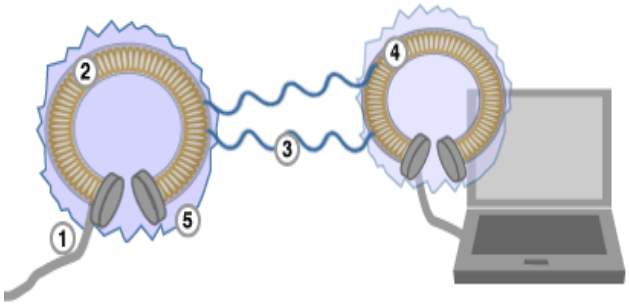
Wireless electricity (Power) transmission basically is the transmission of electricity with the help of microwaves and there is no need to use cables, towers and grid stations [4, 5]. There are three methods or approaches which can be developed. These are as given below:

2.1. Short range (Induction)

This ranges few centimetres e.g. transformer in which transfer takes place due to mutual induction [4, 5].

2.2. Moderate range (Adaptive Inductive Coupling)

Witricity [2] (Adaptive Inductive Coupling) wireless power transfer technology can be used to charge the electronic objects automatically. The ability of our technology to transfer power safely, efficiently, and over distance can improve products. This principle of wireless electricity works on the principle of using coupled resonant objects for the transference of electricity to objects without the use of any wire [4, 5].



1. Power from mains to antenna, which is made of copper
2. Antenna resonates at a frequency of about 10MHz, producing electromagnetic waves
3. Tails' of energy from antenna 'tunnel' up to 2m (6.5ft)
4. Electricity picked up by laptop's antenna, which must also be resonating at 10MHz. Energy used to re-charge device
5. Energy not transferred to laptop re-absorbed by source antenna. People/other objects not affected as not resonating at 10MHz

Figure 1. Working of Wireless Electricity.

2.3. Long range

Plans for wireless power involve moving electricity over a span of miles. Long distance wireless power is the technology of sending power to earth [4, 5]. There are many new techniques but we use only two here.

2.3.1. By using Solar Power Satellite (SPS). This task is often completed by using solar power satellite (SPS) [6, 7], placed in high earth orbit. This satellite converts the sunlight into energy; this energy is composed of microwaves. These microwave signals are transmitted to an antenna on ground/Main grid station (MGS). From MGS these waves are transferred to BGS (Base grid station) so called rectenna which convert microwaves into DC electricity. There will be energy receiver box or energy router in each home. The information of the electricity or power required for each home will be available with the grid station. At the grid station the electricity will be converted into energy packets likewise internet data packets and the header of that energy packet will include the address of the energy receiver that is mounted on the wall of the house of consumer. The energy packet will then reach the energy receiver and will be stored in that energy receiver after that the consumer can use that stored energy any time he wants. We used the same concept as we do in telecom sector and through this act we can buy electricity according to our need.

2.3.2. By using WET Technology (Without SPS). Another method is very simple. We can produce electricity at MGS by (hydropower, Thermal ,Wind, Solar) and convert this electricity into microwaves by using inverse rectennas or Microwave generator and transfer it to base grid station(BGS) so called RECTENNA through transmitting Antennas and from here electricity is transmitted to home wirelessly likewise as explained in section 2.3.1.

2.4. Component detail of WET Technology
The Primary components of Wireless Power Transmission are Microwave Generator, Transmitting antenna and Receiving antenna (Rectenna).

2.4.1. Microwave Generator. The microwave transmitting devices are classified as Microwave Vacuum Tubes (magnetron, klystron) and Microwave Power Module (MPM)) and Semiconductor Microwave transmitters and amplifiers (GaAs MESFET, SiC MESFET, HFET, and InGaAs). Cooker type Magnetron is widely used for experimentation of WPT.

2.4.2. Transmitting antenna. The slotted wave guide antenna, micro strip patch antenna, and parabolic dish antenna are the most popular type of transmitting antenna. The slotted waveguide antenna is ideal for power transmission because of its high aperture efficiency (> 95%) and high power handling capability.

2.4.3. Rectennas. A rectenna is a rectifying antenna; a special type of antenna that is used to directly convert microwave energy into DC electricity. This concept is discussed in SPS detail.

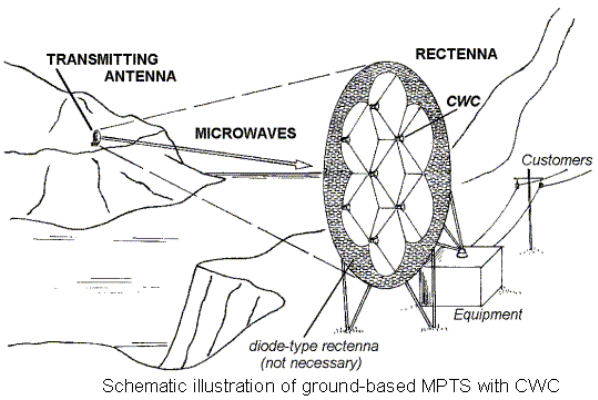


Figure 2. Detail of MPTS.

2.5. Component details of WET using SPS system
The primary components of WET using SPS involve microwaves, solar power satellite, rectenna, dengyo, etc.

2.5.1. Microwaves. Microwaves [3] are electromagnetic waves with wavelengths ranging from as long as one meter to as short as one millimeter, or equivalently, with frequencies between 300 MHz (0.3 GHz) and 300 GHz. For Wireless power transfer we use high power microwaves namely 1-10GHz radio-waves [3, 4, 8].

2.5.2. Microwave power transmission (MPT). Microwave power transmission (MPT) [7, 9] is the use of microwaves to transmit power through outer space or the atmosphere without the need for wires. It is a sub-type of the more general wireless energy transfer methods. Microwaves are widely used for point-to-point communications because their small wavelength allows conveniently-sized antennas to direct them in narrow beams, which can be pointed directly at the receiving antenna [4, 5]. This allows nearby microwave equipment to use the same frequencies without interfering with each other, as lower frequency radio waves do. Microwave Power transfer (MPT) [2.45 GHz or 5.8GHZ] of ISM band is used. (ISM= Industry, Science and Medical).

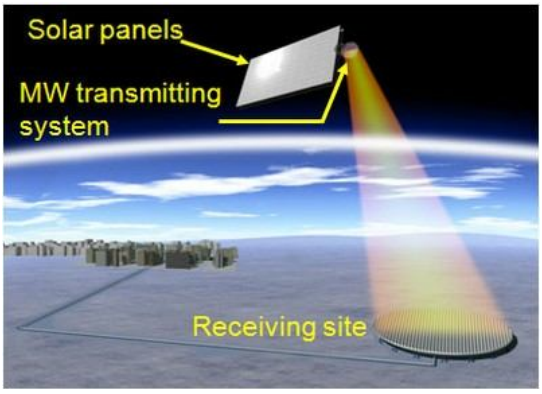


Figure 3. Microwave Power Transfer.

2.5.3. Solar Power Satellites. Space-based solar power (SBSP) [6, 7] is the concept of collecting solar power in space for use on Earth. It has been in research since the early 1970s. SBSP also introduces several new hurdles, primarily the problem of transmitting energy from orbit to Earth's surface for use. SBSP designs generally include the use of some manner of wireless power transmission. It mainly consists of three segments Solar energy collector (To convert Solar energy into DC current), DC to microwave converter and Large antenna array to beam down (Microwave) power to ground [6, 7].

- Solar energy collector (Photovoltaic cell, solar thermal turbine).
- DC to microwave converter (Microwave tube system and /semiconductor system).
- Antenna

SPS will be expected to operate in 2025-2030.

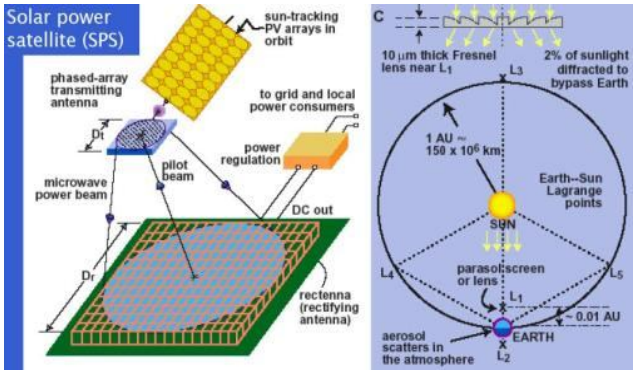


Figure 4. SPS detailed review.

2.5.4. Rectennas. A rectenna [7, 9] is a rectifying antenna, a special type of antenna that is used to directly convert microwave energy into DC electricity. Its elements are usually arranged in a multi element phased array with a mesh pattern reflector element to make it directional. Rectennas are being developed as the receiving antennas in proposed microwave power transmission schemes, which transmit electric power to distant locations using microwaves. Rectennas are used in RFID tags; the energy to power the computer chip in the tag is received from the querying radio signal by a small rectenna. One possible future application is a receiving antenna for solar power satellites.

A simple rectenna element consists of a dipole antenna with a Schottky diode placed across the dipole elements. The diode rectifies the AC current induced in the antenna by the microwaves, to produce DC power. Schottky diodes are used because they have the lowest voltage drop and highest speed and therefore waste the least amount of power due to conduction and switching. Large rectennas consist of an array of many such dipole elements.

Rectennas are highly efficient at converting microwave energy to electricity. In laboratory environments, efficiencies of over 85% have been observed. Some experimentation has been done with inverse rectennas, converting electricity into microwave energy, but efficiencies are much lower - only in the area of 1%. Rectenna conversion efficiencies exceeding 95% have been realized. The efficiency of first Rectenna in 1963 was 50% at output 4W DC and 40% at output 7W DC respectively.

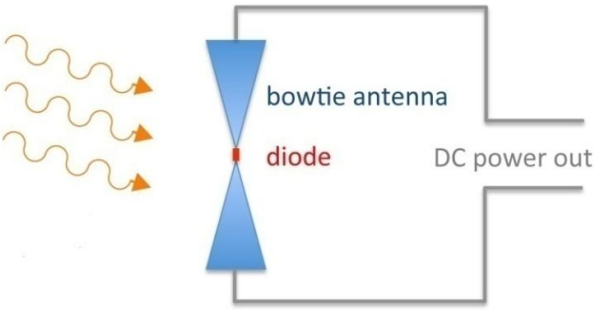


Figure 5. Rectenna.

2.5.5. Dengyo
Dengyo newly developed a microwave-band rectenna and a rectifier circuit and achieved a power conversion efficiency of 90% or higher in the 2GHz band. Dengyo has its strengths in antenna and filter technologies. And the company utilized its know-how in the development of the new technology though it did not disclose details. By using a low-loss filter, it reduced the reradiating of spurious waves from the rectifier circuit to -50 dBc or less.

With the high conversion efficiency, it becomes possible to convert electric waves that have not so far been used by devices using high frequency waves into electricity. Specifically, when the new technology is applied to a microwave heating device, energy that has been discharged as heat can be recycled. And the power consumption of such a device can be reduced by up to 40%.

Because the new technology uses electric waves, electricity can be fed to a distant place. Also, by combining a wireless sensor and the rectenna, it becomes possible to collect data by activating the sensor only when it is necessary. As a result, it eliminates the needs for power wires and primary batteries for wireless sensors.

Nihon Dengyo Kosaku Co Ltd (Dengyo) announced May 16, 2011, that it has developed a technology to convert electric wave into electricity with high efficiency. Specifically, Dengyo achieved a conversion efficiency of 90% or higher by using a rectenna technology that converts the energy of microwave into direct-current (DC) electricity, it said. The company expects that the new technology will be used to reduce the power consumption of microwave heating devices, harvest energy, etc. This time, Dengyo newly developed a microwave-band rectenna and a rectifier circuit and achieved a power conversion efficiency of 90% or higher in the 2GHz band.

Figure 6. Dengyo.

3. Latest researches
Scientists [10] lit a 60-watt light bulb from a power source 7 feet (2 meters) away with their new technique, with no physical connection between the source and the appliance. The researchers have dubbed their concept "WiTricity," as in "wireless electricity."

3.1. First commercial wireless electricity experiment in Japan
Currently Japanese scientists are set to test the largest wireless electricity transmission ever attempted in a Tesla like spectacle that is sure to capture a great amount of attention and spark strong interest and

support for a technology that could change the World. The event is to take place at the Tokyo Tower, the largest man made structure in Japan, at 1100 feet tall.

The night-time experiment is meant to illuminate the top spire of the mammoth steel structure to demonstrate the use of the first wireless electricity transfer system in the World. The test is designed to transfer about 1200 watts of power at a range of 100 feet and will be a first of its kind use of system Japanese scientists are developing to transmit power at distances they hope could reach 300 feet using a science that is based on magnetically coupled resonance.

4. Merits, demerits and applications

4.1. Merits

The major benefits are as follows:

- Remove physical infrastructure “Grids and Towers” [1].
- Cost effective (Remove cost of towers and cables).
- During rain and after natural disaster it is often hard to manage cables and towers so it removes this.
- Losses during transmission and distribution can be removed.
- Microwaves (electricity) are more environments friendly. It does not involve emission of carbon gases.
- Electricity bills using conventional supply can be cut to very low.
- Zero fuel cost [1].

4.2. Demerits

- Biological effects associated with the wireless transmission of electricity due to the high frequency microwave signals is the first demerit of this technology [1, 7].
- This project is a onetime expense but it involves a lot of initial expenditure. It is expected that the price of receive electricity through this technology would decline overtime [7].
- This technology is limited to the use of few technologies like solar satellites and Tesla grid.
- The transmission of electric current through this mode is susceptible to security risks like cyber war fare [1].

4.3. Applications

There are many applications [7]. Example include; fuel free airplanes, fuel free electric vehicles, moving robots and fuel free rockets, battery charging, car charging, remote control, game controller, headsets, sensors, computers, laptop charging, television and many more.

5. Conclusions

This paper provides an overview about the most under discussion technology nowadays. In this paper we, not only tried to overcome the current issues but also discussed the pros and cons of WET technology.

Through this paper we have tried to inculcate the concept of Wireless electricity Power transmission in the mind of readers that by utilizing the power of this technology fully, we can get an efficient, cost effective, wireless(free from wires),losses free environment. Fossil fuel electric power plants generate greenhouse gases which are responsible for global warming. Wireless electricity transmission can overcome these problems well. In the nutshell, this technology will change the concept of Electricity

in near future and make people able to acquire the most efficient, effective, pollution free and healthy way of getting electricity.

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