The Solar Sail and your use into Renewable Energy

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***Abstract*— To discovery alternative sources of energy besides fossil fuels becomes necessary looking for the space. In the space, there is an abundant energy resource: The solar radiation. Solar Sails have long been envisaged as an enabling technology because is a promising low-cost option for space exploration and promissory for space mirror illumination. Actually, we have many projects and research about Solar Sails for space propulsion. However, the idea for space mirror illumination has been forgotten. In this paper, the idea for space mirror resurge with old works about, and demonstrate that is a sustainable energy to research and do.**

Keywords: renewable energy, solar sail, space.

I. INTRODUCTION

Since the beginning of humanity we utilize energy derived from hydrocarbon resources created by natural processes that occurred over eons of time and we are consuming those resources at a rate of millions of times faster than they are being replaced. As more of the world makes the transition to an advanced energy-dependent economy, the demand for energy will inevitably increase and it is obvious that we will eventually exhaust these resources. In addition, production of energy from these resources (generally by combustion) releases vast amounts of pollutants into the atmosphere with results that are not completely understood. This leads to the possibility of global warming with catastrophic effects on our environment [1].

So is obvious, the Humanity need to find new sources of clean energy. Where would one find an external source with plenty of energy and free of charge? It is natural to resort to the nearest star, the Sun. Our Sun is really a stupendous engine producing energy. Deep inside the Sun, an enormous amount of hydrogen is continuously transformed into helium via nuclear fusion. The total energy stored in the solar core is so high that, if the fusion were halted now, the Sun would remain luminous for at least twenty million years [2].

The solar energy is a resource regularly used in the Earth and routinely used on nearly by all spacecraft today. The solar energy available in space is literally billions of times greater than we use today. The lifetime of the sun is an estimated 4-5 billion years, making space solar power a truly long-term energy solution. As Earth receives only one part in 2.3 billion of the Sun's output, space solar power is by far the largest potential energy source available, dwarfing all others combined [3]. Therefore, this technology on a larger scale, combined with already demonstrated wireless power transmission can supply nearly all the electrical needs of our planet. Space solar power (SSP) can provide the needed clean power for any future electric transportation system. Thus, solar power collected in space and beamed to Earth could be an environmentally friendly solution to our planet growing energy problems.

II. SOLAR SAIL'S DEVELOPMENT

The attentiveness of solar sailing can be found back to the 17th century afterward, solar sailing was articulated as an engineering principle in the early 20th century by several authors. Fig. 1, even if solar sail has been considered as a practical means of spacecraft propulsion reasonably freshly, the basic ideas are by no means new. Kepler observed in 1619 that a comet tail faces away from the sun, and conclude that the cause was outward pressure due to sunlight -- a force that might be harnessed with appropriately designed sails. The perception of solar sailing can be found in Jules Verne's book [4]. The inspiration of the solar sail comes from traditional sailing vessels used on Earth. Sailing vessels on Earth navigate with wind sails, which divert a little portion of the massive momentum flux present in moving bodies of air. In space, the solar sail uses the same idea.

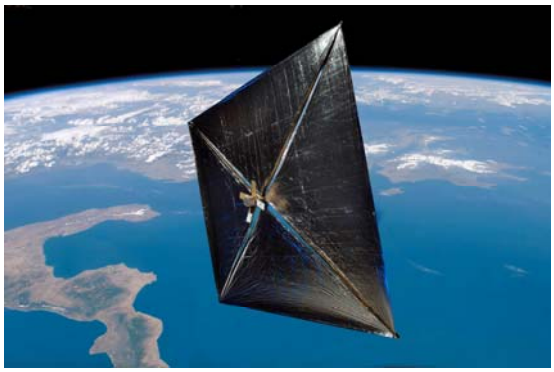

Figure 1. Solar Sail in the Space [6].

Tsiolkovsky [5] proposed that large spacecraft could be propelled through space using photon pressure, and in the same year Tsander, proposed the lightweight solar sail design. Richard Garwin reinvented the modern concept of solar sailing later [6]. In 1960, Arthur C. Clarke wrote a short story, "The Wind from the Sun", racing: Solar sail power interstellar vehicle. Fig. 2, in the same year, Echo-1 balloon felt these solar pressure effects loudly and clearly. NASA had a more positive experience with solar sailing in 1973 when the Mariner-10 spacecraft,, ran low on attitude

control gas. They oriented the Mariner's solar arrays into the sun and used solar radiation pressure for attitude control. The Halley Comet made its closest approach to Earth in 1986, and NASA conceived the exciting idea of propelling a probe via solar sail to rendezvous with the comet [4].

Figure 2. Echo-1. [7]

Maybe, the use of orbiting mirrors to reflect sunlight to Earth for a multitude of interesting applications was originally described in 1929 by the German space pioneer Hermann Oberth in his book entitled "Ways to Spaceflight"[8]. These applications included the illumination of cities, melting of frozen waterways and modifications of the weather and climate. However, professor Oberth was so far ahead of his time that the technology was not available in 1929 to implement these advanced concepts. Thirty-eight years later the treatment of orbiting solar reflectors returns by Buckingham with illumination from space for both civil and military applications. But, Dr. Ehricke papers on “space light” had published the most comprehensive treatment of orbiting solar reflectors, their missions and applications in 1970. His studies cover the broad spectrum of potential applications including illumination, increased plant yield by enhancing photosynthesis, electric power generation, and climate control.

The most intensive studies of solar reflectors for the production of electrical energy were conducted by Kenneth W. Billman, in a study program designated SOLARES. The results of these studies indicated that baseline concept, which used 80000 km orbiting reflectors, could generate 220 GW of electricity [9].

In 1982, NASA published a technical report on the idea of urban lighting, using a type of sailing in a geostationary orbit, reflecting sunlight. It would be deployed in space through the Space Shuttle. The basic idea was to provide industrial densely populated areas dense lighting. The local would be the northeastern United States overnight an area about 330 km across the solar beam. Constellations of lights brighten four or five large urban areas across the country for about two hours. Alaska during winter and the Panama Canal were in the cities also included. The report confirmed the feasibility of illumination from space. However, the project was never realized by the Americans, and only came to succeed later by Russian scientists.

The Russian Space Agency in 1993 launched a mirrored disk 20 meters in diameter, called Znamya 2, in order to project a beam of sunlight on the surface. The Znamya 2 was deployed successfully and a bright spot of 5 km wide across Europe from the south of France in western Russia. The brightness was equivalent to one moonlight night. Originally, the Znamya mirror was conceived as a prototype of a solar sail, but was reassigned as a mirror in space for illumination [8].

In the 21st century, a significant amount of theoretical and practical work has been performed, considering the astrodynamics mission applications and technology requirements of solar sailing [10]. Fig. 3, the JAXA (Japan Aerospace Exploration Agency), in May 21, 2010, launched the solar sail IKAROS (Interplanetary Kite-craft Accelerated by Radiation of the Sun) currently operating successfully in space. It is the solar sail in action with more success actually in the space.

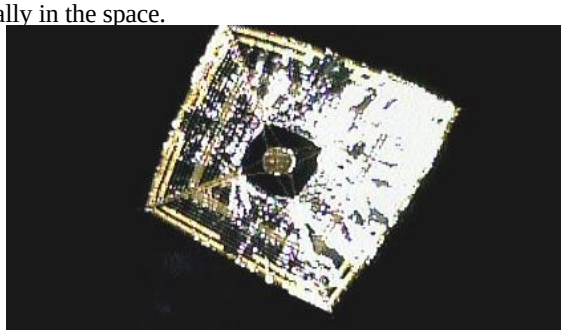

Figure 3. IKAROS – JAXA Solar Sail [11].

Nowadays, the DLR and ESA had been working together in the Gossamer project conducted in stages, these several stages allows to test the structure and technology, which are extremely important, to achieve the necessary reliability for complex scenarios. Moreover, with the same idea, Planetary Society is back with project LightSail, driven by thousands of anonymous donations [4].

III. SOLAR SAIL - SOLAR POWER: RENEWABLE ENERGY

Nowadays, the solar sails have shown great potential for both application with low cost and research. Due to the advance of new technologies are grown up in lightweight deployable booms, ultra-lightweight sail films and small satellite, technologies advancement complexity of low technology readiness level research is typically underestimated due to a lack of recognition of the development degree of difficulty scale. These recent progresses are spurring a renewed curiosity in solar sailing and the missions it enables [4]. Fig. 4 show the basic concept for illumination from space is placed either in a geostationary Earth orbit or on the Moon having the SSP looking down on the Earth at mirrors (reflectors) in an equatorial orbit. Proposed space solar power systems utilize well-known physical principles namely, the conversion of sunlight to electricity by means of photovoltaic cells.

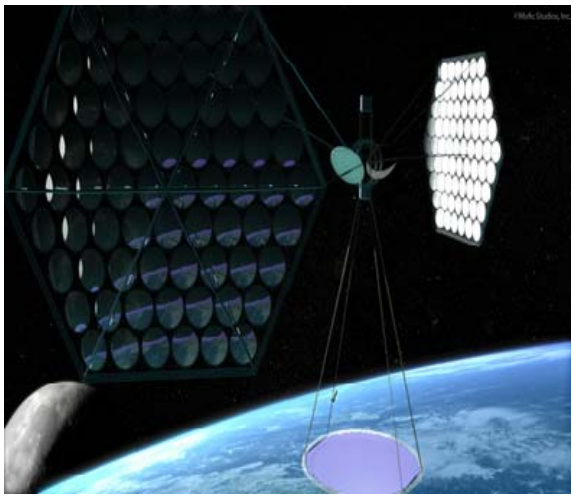

Figure 4. SSP [1]

A complete system would collect solar energy in space, convert it to microwaves, and transmit the microwave radiation to Earth where it would be captured by a ground antenna and transformed to usable electricity. Space based solar power (SBSP) or SSP is a system for the collection of solar power in space for use on Earth. SBSP differs from the usual method of solar power collection in that the solar panels used to collect the energy would reside on a satellite in orbit, often referred to as a solar power satellite, rather than on Earth's surface [1, 3, 8].

Other papers showed new ideas [12], three new concepts for solar power satellites were invented and analyzed: a solar power satellite in the Earth-Sun L2 point, a geosynchronous no-moving parts solar power satellite, and a non-tracking geosynchronous solar power satellite with integral phased array. Some of the advantages are mentioned here as [3, 13]:

- In space, collection of the Sun's energy is unaffected by the day/night cycle, weather, seasons.
- Does not emit greenhouse gases, it works regardless of cloud cover, daylight, or wind speed.
- Does not provide easy targets for terrorists and does not require environment problematic mining operations.
- Space solar power can be exported to virtually any place in the world, and its energy can be converted for local needs.
- Space solar power can also be used for desalination of seawater.
- Space solar power can take advantage of our current and historic investment in aerospace expertise to expand employment opportunities in solving the difficult problems of energy security and climate change.
- Can provide a market large enough to develop the low-cost space transportation system that is required for its deployment. This, in turn, will also bring the resources of the solar system within economic reach.

On the other hand, there are some disadvantages, the cost of implementing such a system, primarily the problem of transmitting energy from orbit to Earth surface for use. Since wires extending from Earth surface to an orbiting satellite are neither practical nor feasible with current technology, SSP designs generally include the use of some way of wireless power transmission. Fig. 5, show the collecting satellite would convert solar energy into electrical energy on board, powering a microwave transmitter or laser emitter, and focus its beam toward a collector on Earth surface. Radiation and micrometeoroid damage could also become concerns for SSP. However, even though the disadvantages, the SSP concept is attractive because space has several major advantages. In geostationary orbit, would be illuminated over 99% of the time.

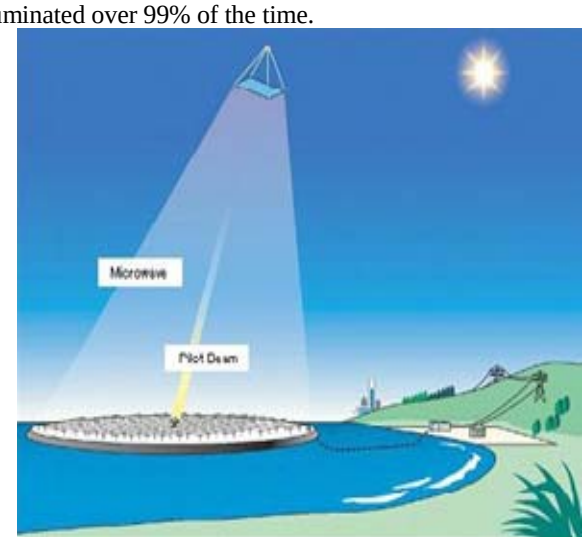

Figure 5. Collector on Earth's surface [14]

Nowadays, Japan works in this project SSP, light power from the sun to Earth. Via an orbiting system of collectors at a large scale may be decades away, cost billions of dollars and require the intervention of some new technologies, the investment can be justified for a country like Japan with limited natural resources, which is still reeling from the Fukushima nuclear disaster [14].

It was Mitsubishi Heavy Industries announced a successful ground test of a system designed to ultimately collect solar power from orbit and beam it back down to Earth in Japan this week. The wireless power demonstration was 10 kilowatts sent over microwaves from a transmitting unit to a receiver unit at 500 meters (1,640 ft.) away. The company did not confirm what percentage of the power was sent to the receiver, however, which is a key question as the ultimate goal is to relay power from orbit thousands of miles above Earth [14].

IV. CONCLUSIONS

The projects presented herein demonstrate a successful use of a solar sail in space exploration. Especially IKAROS operating with excellence in space and Mitsubishi Heavy Industries Project, firsts test were wonderful. The investigations into this matter are developed in several items, such as structures, flexibility, uncertainties, temperature, mechanical, etc. There are a large number of potential markets for space solar power so many positive

aspects of space solar power system appear to outweigh the negative ones. Space solar power is potentially an enormous business. Current world electrical consumption represents a value at the consumer level of nearly a trillion dollars per year; clearly, even if only a small fraction of this market can be tapped by space solar power systems, the amount of revenue that could be produced is staggering. A space solar power generation system can be designed to work in synergy with ground solar power. It is not easy and cheap, but the payoff would be immense and not just in economic terms. If civilization really embraces SSP, a ring of satellites in orbit could provide nearly unlimited energy, ending the biggest conflicts over Earth energy resources. As we place more of the machinery of daily life in space, we will begin to create a prosperous and peaceful civilization beyond Earth surface. The solar power satellites are a potential solution because they can be positioned in space over a particular location to which they can stream continuous sunlight. It is Always Sunshine in Space.

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