Erin Wright

University Physics II

Stewart

Lab H1

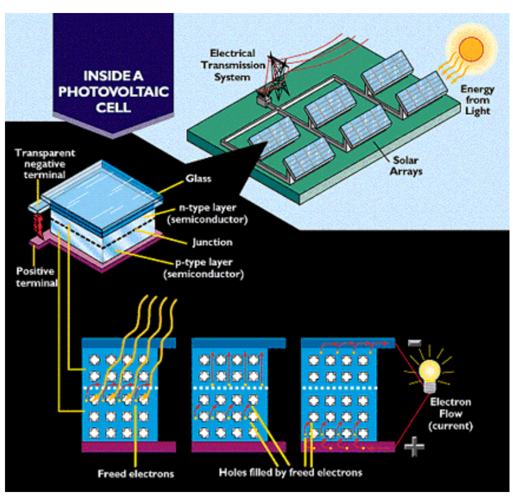
19 April 2010

Solar Technology

The possibility of a world powered by the sun, no longer dependent on burning fossil fuels to keep everything running, might seem like an impossible dream entertained only by the hippies and tree-huggers of the world. But in reality, that dream could be closer than we believe and swiftly approaching. In the past decade, there have been a multitude of breakthroughs in the area of solar technology that improve the feasibility of the idea significantly. They include everything from solar panel design improvements to completely new ideas for expansion of the technology. The physics principles behind photovoltaic technology are also rather simple, though the practical use of these concepts is more complicated to engineer.

The idea that light could be turned into electrical energy was brought up originally in 1839 by the Frenchman Alexandre Edmond Becquerel when he observed an increase in voltage of an electrode that was placed in sunlight (Seale). The first and most primitive version of the solar cell appeared in 1883 and was built by a man by the name of Charles Fritts (Bellis). The first solar cells, even those made from silicon, had a barely noticeable efficiency for storing solar energy. The first commercially valuable discovery in this field of research took place in America in 1954 when the founders of Bell Labs designed the first modern solar cell for production. However, these cells had an efficiency of only about 6% (Bellis). Since that time, efficiency of solar cells, or their ability to convert sunlight into energy successfully has been the ultimate goal.

The physics that allows photovoltaic cells to work revolves around photons produced by the sun. When photons are absorbed by photo cells, they release energy that causes electrons to escape their atoms, leaving a “hole”. The photovoltaic cell is surrounded by two layers of semiconductors that are connected between by a machine or an electric storage device. When the electron escapes its atom, it travels into the top semiconductor, also known as the N-type semiconductor, where it is then transferred to whatever device is being powered or is storing the electric energy. After leaving the terminal, it moves to the bottom, or P-type, semiconductor. Electrons introduced by the bottom semiconductor move to fill the “holes” previously created by the photons (Seale). This cycle results in the flow of electrons, which is the source of the current in the cell. The electric field generated by the two semiconductors accounts for the voltage. And the current and voltage together are power. The process takes place spontaneously as long as photons enter the top layer to remove electrons to the N-type semiconductor and create holes to be filled with more electrons.



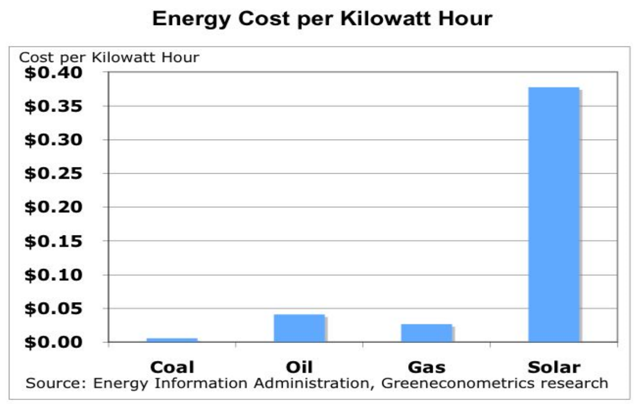
Seale

The engineering problem associated with this idea is the search for a material that absorbs the sun's photons instead of reflecting them. It is impossible to collect solar energy with 100% efficiency, but some materials absorb photons better than others. Silicon has long been the preferred material for use in photovoltaic cells. However, it is not an ideal material because it is not abundant on Earth and at least 70% of silicon is wasted in the process of manufacturing the cells. Scientists have been searching for alternatives to this use and their solutions fall into several different categories; two of which are to either find ways to improve the design of photovoltaic cells and therefore their efficiency, or to make the solar cells based on a completely different concept from the original panels.

Scientists have recently optimized the cells in a few major ways that even made their way into headline news. The company IBM recently introduced a new solar cell design using "copper, tin, zinc, sulfur and/or selenium" which are all naturally abundant resources on Earth, unlike silicon (Hand). This discovery set a new record for efficiency, which is impressive given the difficulty in finding abundant materials that provide a sufficient ratio of absorbed photons (Burnett,10). At the California Institute of Technology, researchers have not abandoned the use of silicon, but have used it in a different form instead. Their design utilizes silicon wires that each "act independently as a high-efficiency, high-quality solar cell," but are formed into an array that is more efficient than each wire alone. The wires are arranged in a clear polymer and because of the scattering reactions between them of photons can absorb about 85% of available sunlight (Upadhvav). This number is a huge increase from the 20 to 40% that is normally expected from solar cells.

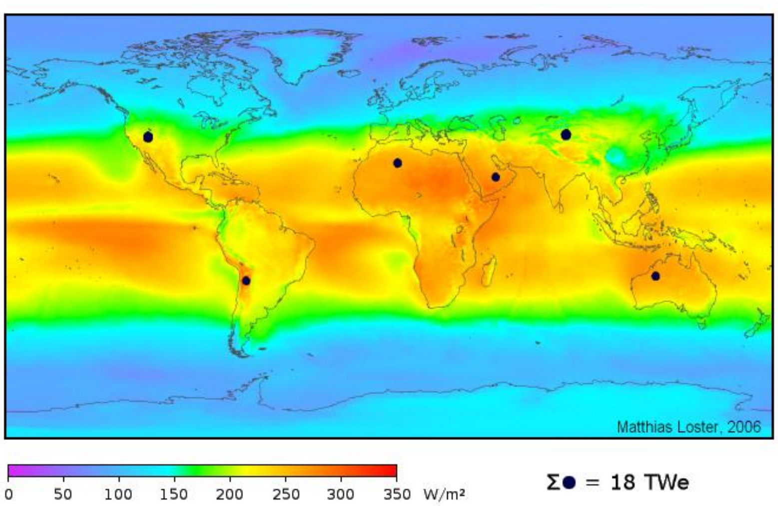
The other alternative to bulky, silicon solar panels is becoming very popular and could become an extremely versatile material. The PowerSheet, developed by a company by the name of Nanosolar, was ingenious enough to win the *Popular Science* Green Tech Grand Award in 2007. It is constructed of nano ink applied to a sheet as thin as aluminum foil and covered in a high-light-transmissive polymer. The cells require no silicon and are as efficient as commercial photovoltaic cells but much cheaper. The rolls of the sheet can be produced at several hundred feet per minute (Moyer). The possibilities for this technology are nearly endless. The sheets of nano cells could be applied to practically any flat surface: house roofs, windows, cars, or basically any outdoors object that requires electrical energy. Nanosolar only deals with the design of the cells, not their manufacturing, but the process of printing sheet of solar cells is surprisingly cheap. Other solar companies have recently started producing similar products of their own and the market for this product is growing. This is especially true since solar cells in this form are much easier to apply in everyday life than a huge array of solar panels all wired together in your back yard.

One major concern with the use of solar power is associated with its price compared to that of burning coal. In order to compete with the price of coal and other nonrenewable resources, the cost of solar energy must decrease to around $1 per watt. It currently stands around $3. The cost of coal in kilowatts per hour is about $0.006 per KWH. Oil and gas are a few cents apiece, but solar energy from solar panels not film or sheets is around $0.38 per KWH (Pearson). This price difference is one main roadblock in solar power dominating the energy market.



Pearson

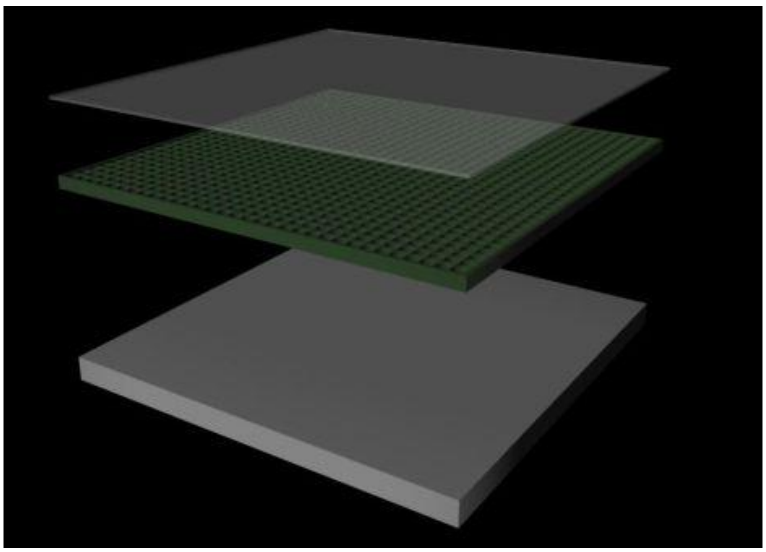
A very interesting and innovative use of new photovoltaic cell technology could be a step towards more widespread use of solar energy. To gather enough energy to power a large system, a massive amount of space is needed to cover with solar cells. But where to get all that space without compromising existing structures? Testing has already begun on the concept of solar cells being made into roads. If all of the area taken up by roads and highways in America were to be covered by photovoltaic cells, enough energy could be produced to satisfy the country's energy demand. The amount of land area required to meet this demand is about 1.7% of the area of the country which is very close to the amount of area covered by roads (Jacquot).



If solar cells covered only the area indicated by black dots, with their efficiency around 8%, the world's energy demand would be more than met.

Wikipedia

The idea may sound pretty fantastic, but it is at least becoming feasible. There are a few details that negatively affect this idea's success, such as materials and cost. To build a road out of solar cells would require three different layers. The top layer would be a high-strength glass with a texture to allow traction of vehicle wheels. The glass would protect the cells and allow light to pass through. Below the glass, the solar cell array would rest on a third layer. The bottom layer would be a base plate to collect all of the



Jacquot

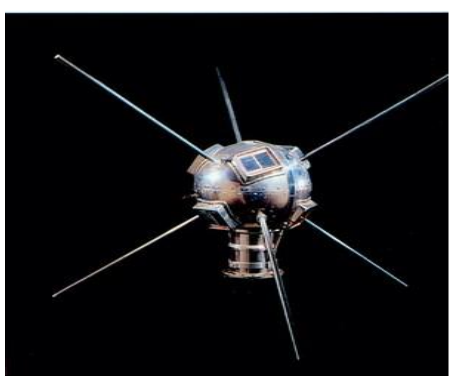
stored energy from the cells and transfer it wherever it is needed. The problem with this design arises in the top layer, the glass. This layer would be vulnerable to the everyday wear of traffic. Accidents could damage the layer and wear from tires would mean that the glass would require constant and expensive maintenance by work crews whose training would also bear great expense. There is also the question of the cost of installing a system such as this. Replacing roads with the solar cells would run into the billions of dollars (Jacquot). However, even though that is no small sum, the excess power provided by the new roads would pay for their construction within a few years, unlike the eight or nine years projected at the beginning of the decade. If a solution could be found to these difficulties, there are several important advantages to this unique idea. The energy stored could be used to produce heat to melt ice or snow on wintery roads, and the array would provide a constant source of energy to electric cars driving above it (George). Electric cars are mainly unpopular because of their need to recharge and the possibilities for problems that need creates. If a constant source of energy were present, electric cars would more than likely become more popular, thus saving Americans money on the cost of gas. A similar use of solar panels to this has already been put into place in Oregon. Where Interstate 5 and Interstate 205 interchange, this is "a row of solar panels about five feet wide and two football fields long" running alongside the roads that generates energy to power of percentage of the lights used along the highway (Rivera). The energy produced is fed into a city wide grid to be used later.

This same technique is the one used for houses that are partially powered by solar energy. The energy captured by photovoltaic cells is turned in DC current. To use this power in homes, a device called an inverter is used to convert the DC current into AC current. Any excess power is transferred into the city grid. And any time the amount of energy collected is insufficient, such as nights or cloudy days, energy can be taken from the city grid to make up the deficit. The power could also be used to charge batteries for later use. For use with homes, most kinds of solar cells would be compatible. The array could be placed on an existing roof, built into the roof, separate from the house and connected by cords, or even covering most surfaces of the house if microfilm like PowerSheets are used. This also applies to businesses, many of which are covering their rooftops with solar panels to lower energy costs in their budgets. The picture below is just one building in a huge initiative by Southern California

Edison, a Californian power company, to cover over two square miles of rooftop with photovoltaic cells (Ehrlich).


Ehrlich

One final area in which the topic of solar energy is prominent is space-based solar power (or SBSP). Every method used to collect solar energy on Earth has the same problem in common: darkness. On the surface of Earth, energy can only be collected during the day, and even then not as efficiently at sunrise and sunset or if the day is cloudy. On a good day, around twelve hours of collection time would be possible. But in space, there is no atmosphere to interfere with the energy from the sun. The first machine to take advantage of this fact was the first solar-powered satellite, Vanguard I.


Wikipedia

Vanguard I had six solar panels spread out around its exterior that let it collect the energy necessary to stay in orbit from the sun instead of an internal source (Hsu). Now, instead of trying to power just a satellite, scientists are taking the concept farther and want to use satellites for a different purpose. One very ambitious goal in the realm of solar power is to use a satellite to collect energy from the sun in space constantly and transmit that energy back to Earth to be used as a primary source of base power. The idea originally came under serious speculation in the 1970s, but was dismissed by NASA as unfeasible due to the fact that too little was known about the “technical, economic, and environmental impacts” of the project (Solar Power Satellites Advisory Panel,3). It was considered too much of a risk. In the 1990s, however, this viewpoint started to change. Technology was advancing enough that this project entered the scope of reality. In 1997, NASA conducted a “Fresh Look” at the project and decided that studies on the subject could begin, mostly because the rising energy crisis made a possible new energy source a higher priority. Through this, the Space Solar Power Exploratory Research and Technology (SERT) program was founded (Wiki). The conclusions they drew seem to be the consensus across the board. Space-bases solar power is a definite possibility for our future. The setup would require a means for collecting solar energy, a transmission device (probably utilizing microwaves), and a receiver on Earth (Solar Power Satellites Advisory Panel, 3). It would receive energy for the vast majority of the year, have a higher efficiency rate, and eliminate the need for storage and waste disposal plants necessary to other forms of energy. Japan is already working prototypes to test this technology for themselves and hope to have and orbiting satellite prototype by 2030. American researchers are studying microwaves in an attempt to find the best way to transmit the collect energy back to Earth (Wiki). Microwaves are the best way to send the energy, but studies are being done to find ways to focus microwave beams to hopefully send more accurate signals from an orbiting satellite.

Solar technology is being improved every day. Some project plans still seem like big dreams with only a small hold on reality. The concept of getting enough energy to power all of Earth just by sending it down from space is still being refined and might not have a significant impact until 2040, but could still be a very important factor in the expansion of solar technology. The use of solar panels on top of roads across the nation has potential for success in the short run, certainly for smaller scale projects like that in Oregon even if not for a nationwide endeavor. Other, more common, uses of photovoltaic cells are already part of many people's lives in the form of solar panels or sheets of photo cells that are applied to houses, businesses, cars, and even outdoor ATMs. As soon as technological improvements decrease the cost of solar energy to where it can compete with that of fossil fuels, solar energy stands a chance in the global market as a renewable source of energy. If this happens, solar energy could also be paired with energy from wind and water turbines so create a power source that is almost completely renewable.

The single concept that a photon from the sun can manipulate the position of an electron in its atom could be the process behind the technology that saves us from the worldwide energy crisis at hand. If we can find a way to efficiently harness the energy of the sun, we can tap into a force that could satisfy our energy needs a million times over.

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