Dr. Jennie S. Hwang

Solar energy—Sweet spot?

Sunlight is the most abundant energy source on earth. It is estimated that the sun shining on the earth for one hour generates enough energy to supply the earth's energy needs for an entire year.

An exploration and use of solar energy that has risen and sunk with oil prices and electricity bills is an old and new thing. Over the years, this hot and cold phenomenon has made many wonder whether solar energy would ever become real. The old is that the solar cell was developed in 1954 with an energy efficiency of 4.5%, and it was fervently explored in the late 1970s during the oil shock. While I was at the last stage of completing my Ph.D. dissertation, I was recruited by a major energy conglomerate to join their photovoltaic team. That was three decades ago!

The new is that the global momentum has finally pushed aside the years of political, economical, technological and social barricades and is moving forward in implementing solar energy. Although solar energy since 1970s has been used in spotty niche applications within or outside the photovoltaic field, it has not been a mainstream business, nor has it been in broad-based deployment until recently.

In the energy arena, America, with only about 5% of the world's population, consumes roughly one-fifth of the world's total energy. Electricity and transportation industries consume the majority of energy. At present, the U.S. total energy sources rely on approximately 40% oil, 23% coal, 22% natural gas, 8% nuclear and 7% renewable, largely from hydropower and bio-mass (The National Academies).

Eighty-five percent of the global electrical energy usage of 13 tera-watts is generated by burning fossil fuels. Energy sources used in generating electricity in the United States (2006) comprise 49% coal, 21% natural gas and other gases, 19% nuclear, less than 2% petroleum, 7% hydroelectric, and less than 3% other renewable.

On the impact of energy usage on the environment

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and climate, carbon dioxide concentration in the atmosphere has risen about 40% since the beginning of the industrial revolution, from 270 parts per million (ppm) to 380 ppm, and is believed to have contributed to global warming and the ensuing climate change. The United States in 2006 emitted a total of 712 million metric tons of carbon, 412 million metric tons of which came from road petroleum use (Energy Forum—James A. Baker Institute.) The country emits more energy-related carbon dioxide per capita than any other industrial nation, approximately one fourth of the world's greenhouse gases, and its CO_2 emissions are projected to continue to rise, as is worldwide emissions. It is a concern.

Solar energy is one of the viable renewable energy paths. Yet solar energy is less than 0.1% of the world's electricity supply. It is miniscule indeed. As energy needs are mushrooming throughout the world, particularly the phenomenal growth rate in the developing countries, every bit of energy supplement counts. By integrating with other renewable, alternative and conventional energy sources, the uncertainties surrounding energy supplies from politically volatile regions can be eschewed. As a 'clean' energy, it further circumscribes the much concerned carbon footprint.

In the recent few years, government incentives bestowed to solar energy has been largely outside the U.S., and the U.S. Congress has failed to include the solar energy in the most recent energy bill (2008). Countries like Germany, Japan, Spain and Australia are the vanguard in implementing solar cell energy.

With a small economics to start, solar energy provides ample growth opportunity in business and in technology. The consensus on anticipated growth rate falls around 25 to 50 percent, varying with geographic locations and other factors. Technology advancement to increase the photovoltaic solar energy conversion efficiency and to decrease the usage cost will continue to be the thrust for future deployment of solar energy.

The sun's energy has been used through different technological approaches:

- Photovoltaics
- Solar heating, where collectors absorb the sun's energy to provide low-temperature heat (such as for swimming pools)
- Solar lighting, where collectors focus light into a fiber optic system to illuminate buildings
- Concentrating solar systems, which use reflective materials that concentrate the sun's heat energy to drive a generator that produces electricity
- Other sunlight concentrating technologies
- Other technological paths

Within photovoltaics, the scientific principle for solar cells is straightforward. When the sunlight shines on the semiconductor solar panel, the light can be reflected, pass through or be absorbed. The absorbed sunlight (photons) by the solar panel is converted to electrons in the atom structure of the semiconductor of the solar cell material, resulting in electrical current in an electrical circuit.

It is a photon-electron conversion. But the conversion efficiency, thus economics, calls for ever-continuing technological breakthroughs.

In application, a solar panel consists of several major components and steps: making solar cells, assembling modules, connecting arrays and installing systems. Manifold supporting technologies, products and services, ranging from materials to equipment to testing and measurements, are also the central part of the industry.

Overall, photovoltaics rely on the power play of the atom, the relentless energy of photons and the free path of electrons.

Today, photovoltaic cell technology can be grouped into three generations: thick film/ bulk polycrystalline silicon, thin film/amorphous silicon or other substrates, and nano-based or organic cells. At the time of this writing, the first generation

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occupies the majority of commercial applications.

Solar energy in heating and cooling and other vehicle electronics—sensors, computers, electric motors—also contribute to future fuel-efficient military and commercial vehicles.

On the global stage, it is generally viewed that the lower the ratio of a country's energy consumption to gross domestic product (GDP), the lower the cost of the tradeoff between inflation and GDP loss. Oil imports account for two-thirds of U.S. oil consumption. Higher U.S. oil imports not only enhance OPEC's monopoly power, they also have a deleterious long-term impact on the U.S. economy.

Future energy portfolios will be concocted by availability, supply stability, price stability, affordability, sustainability and security. With or without the energy-independent and carbon-free ideals, with and without government's incentive stimulus, the strategy and action to meet future energy demand can only be accomplished by the combined strategies of energy conservation, energy diversification (fossil fuel, alternative energy and renewable energy) and technological advancement.

Among the emerging technologies, in ostentatious nature and in obscurity, solar energy's deployment takes bold initiatives. The global initiatives are burgeoning.

China's government has pledged $100B allotments on renewable energy to make renewable energy account for 15% of total energy supply by 2020. The EU is driven by its goal to increase renewable energy penetration in the region of 27 member states to 19% by 2010. Germany, a leader in solar cell energy use, is encouraged by the government's goal to increase 100 MW/yr and incentives to build plants producing solar energy products. Japan, another leader in PV technology, set application targets of an increase in PV electricity generation by 400MW/yr through 2010 and is expected to extend its incentive program for renewable energy (during a congress meeting in August, 2008). Taiwan's government has also designated solar energy (and LED) as a strategic industry, committing to increasing its production capacity, subsidizing manufacturers' R&D and offering incentives to consumers who use solar panel energy. Among the U.S. corporations and institutions, Google announced their investment in renewable energy, establishing an R&D group, and Intel also is investing in multiple solar energy development.

With global energy activities, what are the resulting geopolitical ramifications?

In a nutshell, energy is the racing game of technology and deployment, which is a sweet spot in global competitiveness. Photovoltaic electricity is the story of the power play of atoms, the energy conversion of photons and the free path of electrons. As to solar energy, no country can capture another country's photons, which is the sweet spot.

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Dr. Jennie S. Hwang is inducted to the WIT International Hall of Fame, elected to the National Academy of Engineering, and named an R&D-Stars-to-Watch (Industry Week). She is a member of the U.S. Commerce Department's Export Council, and serves on the board of Fortune 500 NYSE companies and civic and university boards. She has served on National Research Council's "Globalization Committee" and " Forecasting Emerging, Disruptive Technologies Committee", among others. In addition to technical publications, she is an international speaker and author on trade, business, education, and social issues (www.JennieHwang.com). Contact her at (216) 839-1000; e-mail JennieHwang@aol.com.