Future of Energy

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Civilization is presently in the hunter/gatherer mode of energy production. Nonetheless, the continual drop in cost of solar panels will lead to an agrarian model in which energy that is harvested from the Sun, optically, will satisfy all of society's needs.

Solar panels are optical. By recognizing the optical physics in solar cells, scientists are, for the first time, approaching the theoretical limit of ~33.5% efficiency from a single bandgap.

At the same time, solar panels have dropped in price by a factor of approximately three times per decade, for the last four decades, cumulatively a ~100-fold reduction in real price. Since solar panels are manufactured in factories under controlled conditions where continuous improvement is possible, these panels will continue to drop in price until solar electricity becomes the cheapest form of primary energy (likely to occur around 2030). At that point, solar electricity will become cheap enough to be converted into fuels, which can be stored summer to winter. The creation of fuel requires panels that are three to four times cheaper than today's already depressed solar panel cost, while maintaining the highest efficiency.

The highly successful petroleum industry is over 150 years old. It has taken advantage of technology, but it appears resistant to disruptive technical changes that could sweep it away, as so many industries have been irrevocably changed or entirely eliminated by the advance of technology. Nonetheless, the application of solar electricity to create fuel could sweep away the petroleum exploration industry, which the author calls the "hunter/gatherer" mode.

Future solar cells will all have direct bandgaps, allowing them to be very thin. The cost of the material elements composing the cell will be small, since a film as thin as 100 nm can fully absorb sunlight using light trapping. Even if the chemical elements were to be expensive, there would be so little material used in such thin photovoltaic films that the cost would be low. Indeed, there are methods to produce free-standing, highest-quality, single-crystal thin films economically.

The key to high performance from a solar cell is external luminescence efficiency, an insight which has produced record open-circuit voltage and power efficiency. This has everything to do with light extraction, in agreement with the mantra "a great solar cell needs to also be a great light emitting diode"—again the application of optics.

Solar electricity in the open field will be brought to nearby locations where it will be used for the recycling and electrolysis of CO_2 solutions. There have been great strides in electrolysis, which can produce various proportions of H_2, CH_4, and higher hydrocarbons as products. The carbon–carbon bond is particularly prized, since such compounds can be readily converted into diesel fuel and jet fuel. The study of such selective electro-catalytic surfaces is still in its infancy. Even if only H_2 were ever to be produced, there are industrial methods of using H_2 to reduce CO_2, and make useful liquid fuels, among many other products.

The ability to create fuels would increase the size of the photovoltaic panel industry at least tenfold, allowing the adoption of new cell technology, which is better than the current outdated 1950s crystalline silicon solar cell technology.

Thus we see that the application of optical science in making solar cells more efficient and lower in cost will produce a revolution in mankind's energy source, playing a role analogous to the agricultural revolution of 10,000 years ago.