Solar Cells vs. Plant Cells: In Defense of Chlorophyll

by Oyang Teng and Sky Shields

The adoption of the North American Water and Power Alliance (NAWAPA) project will inaugurate an era of continental-scale infrastructure development that will revolutionize the very idea of infrastructure as mankind's conscious management of the biosphere. As Vladimir Vernadsky wrote in 1945, "Mankind taken as a whole is becoming a mighty geological force. There arises the problem of *the reconstruction of the biosphere in the interests of freely thinking humanity as a single totality*. This new state of the biosphere, which we approach without our noticing, is the noösphere."[1]

Who would dispute that the vital interests of "freely thinking humanity" include provisions for plentiful, clean water, and the benefits of vast new areas of greenery, moderating climate and making the planet more habitable and life more enjoyable—especially in desert areas where the biosphere has more or less retreated? This kind of true Green jobs program would, unlike large-scale schemes for solar panels, use the power of the Sun, combined with the effort of man, to actually bring green to areas that need it.

What Is Solar Power, Really?

Ancient peoples (and modern-day pagans) worshipped the Sun for obvious reasons: It sustains all life on Earth. Through increasingly sophisticated space-based telescopes, we have learned much about our Sun, although we are still just beginning to understand its intricate structure and the fusion processes which drive it. These processes produce the outward flow of electromagnetic radiation bathing the Earth, and the entire Solar System, at every moment. Most of this solar radiation is in the form of invisible ultraviolet and infrared frequencies, as well as the spectrum of visible light.

Over time, life on Earth has managed to make ingenious use of this entire range. Our own capacity for sight is only the most obvious case. For example, the "scents" utilized by moths and other insects for communication and navigation, actually involve the detection of various narrow-band infrared frequencies emitted by airborne scent molecules within specific infrared "radiation windows" of the atmosphere. Many insects and other animals also have eyes adapted to see in the ultraviolet range. But the most important use of solar radiation by living organisms is photosynthesis, the direct conversion of visible light into usable energy for plant and animal life, and oxygen to breathe.[2]

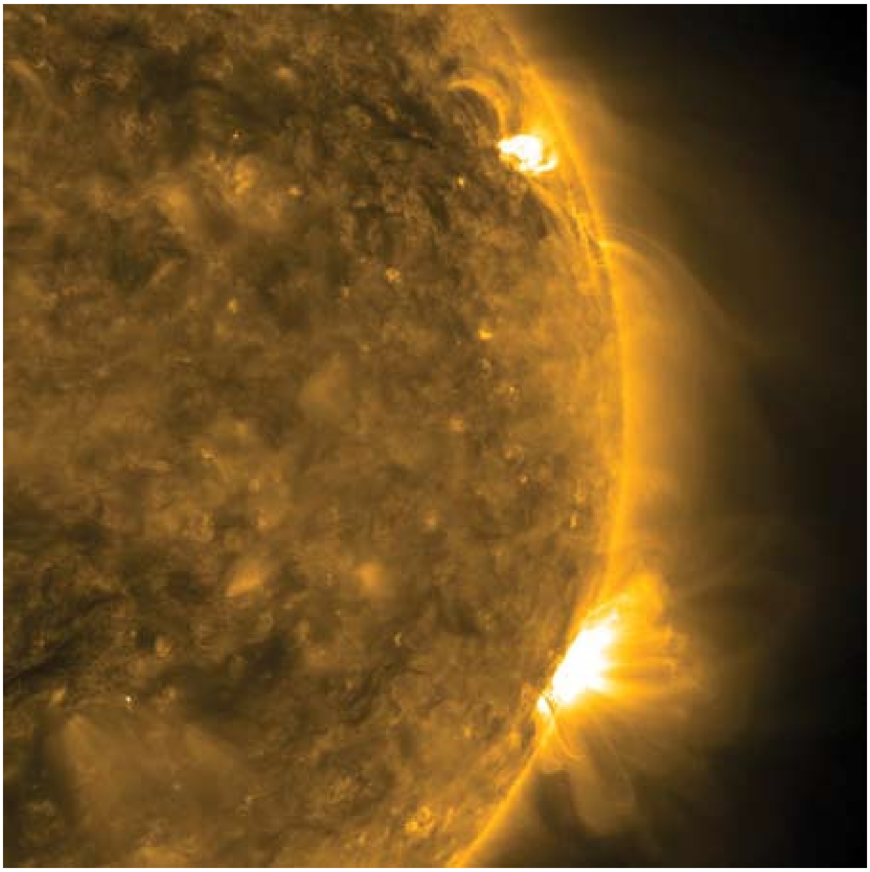
We can thank photosynthesis, and the humble little

1. Vladimir Vernadsky, "Some Words About the Noösphere," *21st Century Science & Technology*, Spring 2005. http://www.21stcenturysciencetech.com/translations/The_Noosphere.pdf

2. Some non-oxygen-producing photosynthetic bacteria make use of infrared light. A new study has also indicated the existence of a new form of oxygen-producing bacterial chlorophyll (Chlorophyll f) which utilizes light in the near-infrared range.

Ralph M. Parsons Co.

NAWAPA will divert a portion of Alaskan and Canadian freshwater runoff into the Great American Desert, as shown in its original design by Ralph M. Parsons Co. in 1964.



NASA

A close-up of the Sun, taken by the Solar Dynamics Observatory, in the ultraviolet range.

chlorophyll molecule that makes it possible, for the fact that Earth is neither an ice ball, nor a Venus-like super greenhouse. Instead, the surface of the Earth exists as a concentrated region for the transmission and transformation of cosmic and solar radiation, through the action of living organisms. At least 2.5 billion years ago, photosynthetic organisms began pumping oxygen into the atmosphere, resulting in the protective ozone layer, and the stabilization of the hydrosphere. This accounts for the existence of the planet-wide circulation of water through its liquid, gaseous, and solid form, to a large degree shaping Earth's climate, as well as the chemical composition and tectonic activity of its crust.

For all this work, only a vanishingly small part of the total amount of radiation given off by the Sun actually reaches Earth, and only a portion of that is utilized by photosynthesizing organisms. At the top of the atmosphere, an average of approximately 340 watts per square meter of energy arrives from the Sun. About a quarter is reflected immediately back into space. Another quarter is absorbed by the atmosphere, leaving roughly half to pass through to the surface, where an average square meter receives about 170 watts. Where it meets green plant life, this relatively weak incident sunlight is put to work to great effect, helping to drive the so-called energy cycle of the whole planet.

But, where sunlight meets barren desert land, it is wasted, largely unused by life.

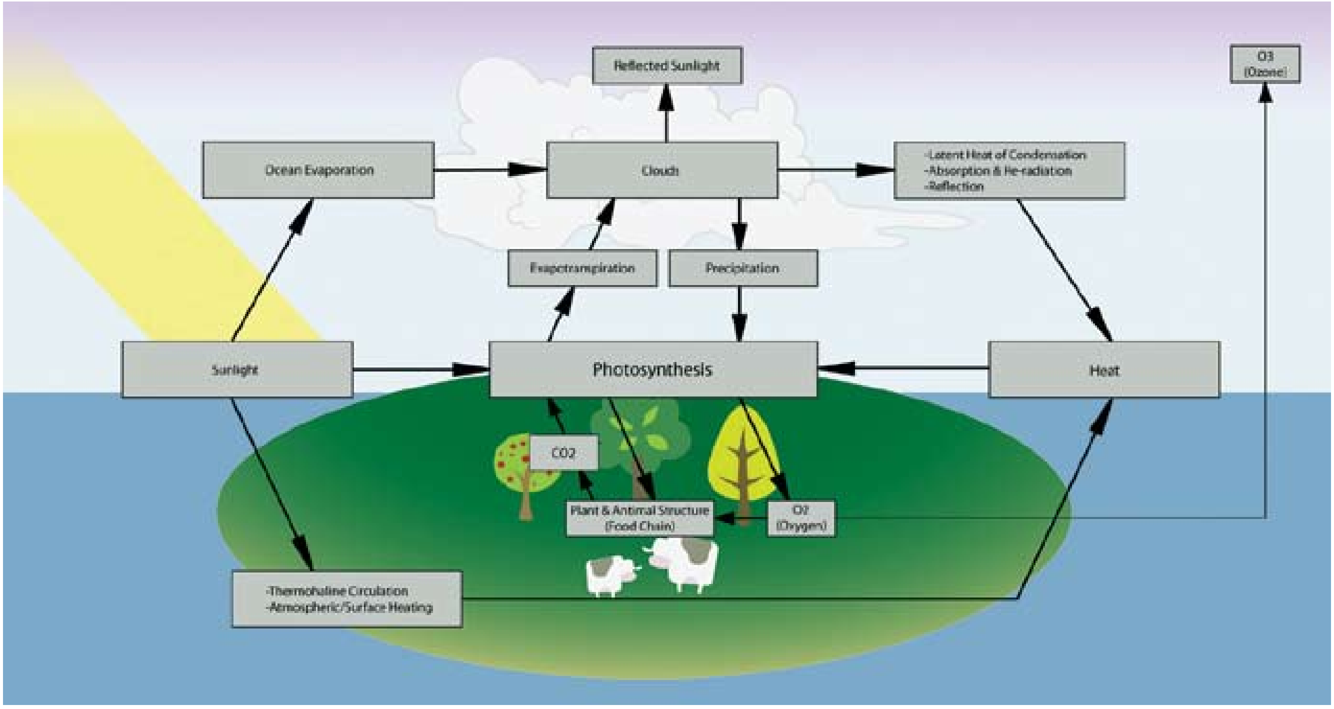
In effect, deserts represent failures of either nature or man. Desertification appears to be on the rise in certain areas around the globe. Luckily, NAWAPA and similar projects will make such seemingly daunting problems trivial. Increasing biomass (which, incidentally, would likely benefit from marginal increases in atmospheric CO_2) through well-planned tree planting and irrigation, has been shown to improve local climatic conditions, increasing moisture recovery and rejuvenating the soil. A pair of Russian scientists have also proposed a theory called the Biotic Pump, claiming that coastal forests, through intensive evapotranspiration, draw in moisture-rich air from the oceans to fuel extensive precipitation and evaporation cycles into the far interiors of continents.[3] Specially planned new forests would provide a modern twist to the old pioneer adage that "the rain follows the plow," and deserts on every continent could be made to bloom.

The prospect of unleashing the full potential of the biosphere by transforming deserts into fertile forest and agricultural lands, a task placed in the hands of man as planetary gardener and engineer, is undoubtedly the greatest exemplar of "going Green" in history. On the other hand, those who advocate maintaining the "natural" dessication of these landscapes, with wasteful plans for solar panel installations, appear to have "gone Brown."

---

3. A.M. Makarieva and V.G. Gorshkov, "Biotic pump of atmospheric moisture as driver of the hydrological cycle on land," *Hydrol. Earth Syst. Sci.*, 11, 1013-1033, 2007 http://www.bioticregulation.ru/common/pdf/07e01s-hess_mg_.pdf

FIGURE 1
Photosynthesis and Life



LPAC

Photosynthesis and the Biosphere

Let's take a more detailed look at where photosynthesis is situated with respect to the processes of the biosphere as a whole, in order to properly understand the danger posed by solar cells (**Figure 1**).

First, sunlight warms the atmosphere, surface, and oceans. Thermohaline currents, also known as the global conveyor belt, which depend on the relative temperature and salinity of ocean water, moderate atmospheric temperatures as they circulate around the globe. Evaporation from the oceans produces atmospheric water vapor and clouds. Plants also contribute to moisture and cloud formation over land. The extensive surface area of vegetation, optimized for the maximum capture of sunlight, leads to significant evaporation of captured rainfall, while transpiration releases water drawn by roots from soil kept moist by plant cover. Evapotranspiration also helps to cool arid regions by direct evaporative cooling.

Scientists are only beginning to understand the contribution of terrestrial vegetation to the global water cycle, especially the process of moisture recycling over land, but these contributions appear to be much more important than previously thought. It is estimated that in heavily forested regions like the Amazon, water from the oceans might be recycled up to six times through evaporation and precipitation, a process driven by, and necessary for, photosynthesis.

In addition to precipitation, clouds play an important role in moderating temperatures, as well as driving the so-called heat engine of the climate. To begin, clouds reflect incoming sunlight—the more clouds, the lower the temperature. But, there are also a number of ways that clouds radiate heat into the atmosphere: by reflection of surface heat, by absorption and re-radiation (cloudy nights are warmer nights), and by the latent heat of condensation, in which water vapor changes its state from gas to liquid, releasing the energy it took to evaporate it in the first place.

Indeed, the study of the role of water in the atmosphere is another area that exposes how little is actually understood about the biosphere as a structured medium, organized, in all respects, by the activity of living organisms. Just as the protoplasm of a cell assumes a definite organization beyond acting as mere solvent, so too, does the atmosphere manifest the unique structural properties of water. Consider the

Athena's Picks, http://www.flickr.com/photos/23045224@N04/3205676821/

When solar radiation meets with green plant life, good things happen.

strange case of noctilucent clouds, formed at the edge of space in the very upper reaches of the atmosphere, where the extremely cold air is 100 million times drier than that of the Sahara, yet clouds of ice crystals are still somehow able to form.

In examining the total flow of solar energy through the biosphere, it is important to point out that the efficiency of photosynthesis cannot be strictly measured in the same thermodynamic terms as used for abiotic systems. Almost none of the heat evolved in these processes is "waste heat," but, rather, it provides the necessary operating conditions for photosynthesis, and virtually all life on the planet. If plants were 100% efficient at absorbing solar radiation, reflecting none as heat, the Earth would freeze over—not very conducive to photosynthesis.

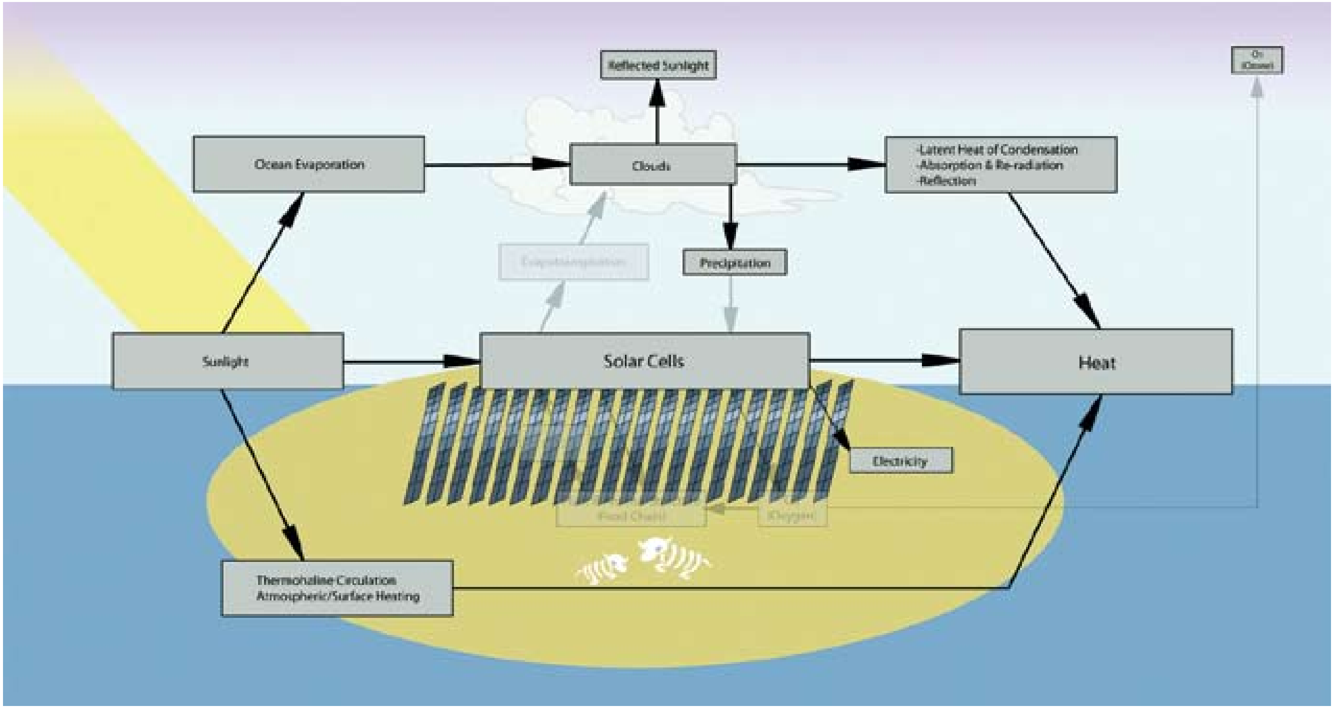
Aside from climatological effects, the other primary products of plant photosynthesis are carbohydrates and oxygen. Carbohydrates form the structure of plants and animals, and the basis for the entire food chain. That is, photosynthesis takes sunlight and literally builds it into the structure of the biosphere. Oxygen feeds into the respiration of plants and animals, a process which, in turn, produces the carbon dioxide needed for photosynthesis. Oxygen also feeds the production of ozone, which, in the upper atmosphere, helps to filter the more damaging forms of ultraviolet radiation.

Though simplified, this picture suffices to give a sense of how centrally photosynthesis figures in the regulation of the biosphere. Modeling these relations to forecast future changes in the system, particularly those changes we wish to willfully induce, will require a "systems" treatment that goes well beyond current methods used for constructing climate models. Yet, one already can see represented here the basic features of the so-called water, carbon, and oxygen cycles, all intersecting through the process of photosynthesis. These form merely a part of the total biogenic migration of atoms through the biosphere, identified by Vernadsky as the primary expression of biogeochemical energy, a magnitude which has steadily increased over the geological history of the planet.

Such is the potential unleashed by greening the deserts.

With this picture in mind, let us now substitute solar cells for the role of chlorophyll, and watch our biospheric function collapse (**Figure 2**).

FIGURE 2
Solar Cells and Death



LPAC

Why Green Plants Hate Solar Cells

Solar panels typically absorb about 20% of incident sunlight for conversion to electricity. They contribute nothing to moisture recycling, and obtain no benefit from precipitation. In fact, they are most effective with absolutely no clouds in the sky.

Whereas the biogenic migration of atoms is accelerated through the various biogeochemical cycles intersecting at photosynthesis, it is disrupted by the presence of solar panels. Further, unlike plants, solar cells produce, but do not consume, heat in their operation. That is, much of the sunlight that hits a solar cell is either reflected or absorbed as heat, without inducing an electrical current. This heat, as well as that produced in the movement of electricity through conducting wires, constitutes waste heat. In fact, solar cells work best at the frigid temperatures found in the vacuum of space.

Then there is the problem of dust; it is estimated that less than a tablespoon of dust per square meter can reduce the efficiency of a typical solar panel by 40%. This is roughly the amount deposited in one week in the desert. Dust, which is a major worldwide export of deserts like the Sahara, also represents a major ecological threat, as well as a serious human health hazard from—among other things—infectious diseases that can be carried with it when blown across the ocean.

But solar panels themselves also pose a direct threat to the survival of living organisms. Certain species of aquatic insects, which lay their eggs in water, are attracted to the polarized light reflected by solar panels, mistaking it for the reflection from water. This spells doom, not only for the eggs which get cooked on the panels, but also for the insects which, enchanted by the siren shimmer of these false oases, exhaust themselves to death by endlessly flying around them. Whole insect species could be wiped out by such "eco-friendly" installations.

In sum, it appears that the prime location for a solar panel is a barren stretch of desert (possibly paved over to eliminate the dust), with no cloud cover, no plants that might provide unwanted shade, and no insects or other forms of life that would either be endangered by, or otherwise interfere with, its operation—at least, on sunny days.

USAF

A solar panel array in the Nevada desert: insects, beware!

Viewed from the standpoint of the Earth as a system, the usage of solar energy by solar cells represents an overall increase of heat and moving electrons, or a quantitative increase in heat and motion. Now compare that to the process of photosynthesis, where the solar energy is used by the plant to (ultimately) split water, and fix carbon dioxide, producing oxygen and carbohydrates. In this case, the solar energy is being converted into the structure of living organisms on the planet. Add to that the fact that the plant is producing oxygen and moderating climatological effects, and one can see that solar energy is being converted into both the structure of higher organisms and the conditions for those higher organisms to survive.

The expression for our Earth's transformation now is no longer a simple quantitative increase, but a change in the entire geometry of the process. This is even more true, if it is recognized that the structures produced by plant life don't fuel only the *survival* of living organisms, but also their evolution to higher states of organization. That is, it is not merely cycles of energy per se, but, rather, increases in energy-flux density—the greater organization and throughput of energy on the planet as a whole—which power the biosphere.

These qualitative aspects are, to some degree, reflected in certain simple quantitative considerations.

For example, a single molecule of oxygen (O_2) is liberated by splitting two water molecules during the course of photosynthesis, a process which involves the transfer of electrons through the entire photosynthesizing apparatus. Each H-O bond requires about 4.22 electron volts (eV) to form or break. The shortest visible wavelengths pack only 3.1 eV per photon, and the energy goes down with longer wavelengths. Therefore, the only light that can break hydrogen from water is ultraviolet or shorter wavelengths. But, the shortest peak wavelength of activation found in chlorophyll is about 435 nanometers, in the deep violet, not ultraviolet range. Other chlorophylls operate down into the infrared (such as the newly discovered "Chlorophyll f"). Therefore, the advent of chlorophyll and the photosynthetic apparatus represented an upshift in the energy-flux density delivered to the surface of the Earth in the form of sunlight.

What is significant is the absolute distinction between the process of electron transfer involved in the operation of solar cells, versus that in the operation of photosynthesis, processes which, superficially, may seem broadly analogous.

Solar cells operate by the photoelectric effect, in which incoming sunlight excites electrons within a semiconducting material such as silicon to a higher energy level, leading to the movement of free electrons, which eventually pass into an external circuit to maintain a flow of electricity.

In plants, an incident photon of sunlight also excites a single electron in the chlorophyll molecule, bumping it up to a higher energy level. Before it drops back to its ground state, as described succinctly by a pioneer researcher in photosynthesis, "Life puts itself between these two processes and makes the electron drop back within its own machinery, utilizing its energy. . . . In order to do this efficiently it must meet the electron with a specially built substance (mostly chlorophyll) and couple this substance to a system which converts the very labile electronic excitation energy into a more stable chemical potential, into chemical energy."[4]

In reality, it is still unclear what happens within the photosynthetic apparatus, between the input of light and the output of carbohydrates and water, though many intermediate steps have been enumerated over decades of experimentation. The actual process of electron transport during photosynthesis defies a simple, stepwise description of particle motion. For one thing, it operates at nearly 100% efficiency, which is nowhere approached in the abiotic domain, except under extreme conditions, such as superconductivity at near-absolute zero temperatures. In such phenomena, the discreteness of individual "particles" no longer applies.

Here we see the importance of understanding the fundamental distinction among the living, non-living, and cognitive domains. The transformative power contained in the highly organized organic matter produced by photosynthesis lies in its irreplaceable function in directly supporting life, including human life.[5] For the industrial processes on which human society depends, we turn to nonliving processes in the atomic and subatomic domains, capable of producing work in the form of heat or electricity, at energy densities millions of times greater than incident sunlight. Indeed, the solar energy contained within the organically derived molecular bonds of fossil fuels has reached the limits of its usefulness as an energy source for mankind, requiring a turn to sources of much higher energy-flux density, such as nuclear fission and thermonuclear fusion, which will be the platform technologies for spacefaring humanity in the years to come (since it would certainly be a shame to let all that Helium-3, an ideal fusion fuel source that the Sun has been generously implanting on our Moon for billions of years, go to waste).

Green Jobs for Chlorophyll

For those who, after all this, would still insist on solar cells, we offer an appeal to conscience on behalf of the firefighters of the world, given the extreme hazards of solar-panel-related fires which have recently come to light.[6] Add to the fire danger, the ridiculous production costs of solar power compared to its output,[7] and it becomes clear that solar cells represent not only an ecological, but a societal menace of major proportions.

In our concern to utilize all the "free" sunlight being delivered to Earth, we should remember not to neglect the infinitely greater amount streaming unused throughout the entire Solar System. Putting this solar radiation to work means extending the activity of life into that Solar System. Greenhouses in Earth orbit might be a good start, on the way to colonizing the Moon and Mars—a mission we will begin by fully terraforming our own planet through NAWAPA. To accomplish this, we will employ millions of people, relying especially on the skilled scientists, engineers, and construction specialists whose knowledge is crucial in driving a physical-economic mobilization unparalleled in history. We will also employ the productive labor power of the humble little chlorophyll molecule on a vastly expanded scale. Isn't that, after all, a real Green policy?

Peter Martinson and Michelle Lerner contributed to this report.

Contact: basement@larouchepac.com

---

4. Albert Szent-Györgyi, *Introduction to a Submolecular Biology*, 1960.

5. That is not to say that photosynthesis itself could not be improved by man. This would be among the goals of any properly designed space colonization effort, for example, as described in the following excerpt from Lyndon LaRouche's 1980 book, *There Are No Limits to Growth*, in the chapter entitled, "The forests and cities of Mars":

"With relatively abundant energy supplies, and vastly improved technologies for using it, one of the most irritating features of nature for scientists and administrators will be the poor performance of biological processes in making use of energy available in larger flux densities. We cannot blame the plant species of Earth for their poor performance on this account. . . . It is the poor quality of solar power to which the Earth's plant life was obliged to adapt itself. Considering the fact that that plant life 'invented' chlorophyll, we must congratulate our plant species for doing as well as they have done, in managing to produce our biosphere, despite the miserly treatment our plants have suffered at the hands of the Sun. Now, as we make available to plants much higher energy-flux densities, available to the friendly plants in almost any form they might desire their energy nourishment to be served to them, we must somehow communicate this good news to our plant species. In brief, we must accelerate the useful reproductive rates of useful biomass, especially as food chemists, such as J. Liebig and L. Pasteur, started us on this road during the last century; now in the age of fusion beam technology, we must take a giant step forward along the same road."

6. http://tiny.cc/uiufw, http://www.21stcenturysciencetech.com/Articles_2010/Deadly_panels.pdf

7. Larry Hecht, "The Astounding High Cost of 'Free' Energy, *EIR*, Feb. 13, 2009, http://www.larouchepub.com/eiw/public/2009/2009_1-9/2009-6/pdf/04-10_3606.pdf