PRESIDENT'S MESSAGE
By Al Tucker

Solar Arrays in AA County

Recently, there has been a rush to develop solar photovoltaic facilities on farmland in Anne Arundel County. Many citizens have objected to the development on the grounds that it removes farmland from production, further exacerbating the loss of agriculture and open space. Others assert that direct conversion of solar energy to electricity mitigates the production of greenhouse gas, carbon dioxide (CO_2), from fossil fuels. While the focus has been on the attractive economics of solar, it is often taken for granted that solar energy is inherently environmentally sustainable and that its carbon credentials don't require scrutiny. Hence, one draws the conclusion that solar photovoltaics (PVs) are "green" and "sustainable" and, therefore must be good for the environment. This idea has led me to reexamine the bases for trading one ecological service for another and poses the following question: is one ecological function more valuable than the other?

As with most energy sources, we place too little value on the effects on our health, or the fact that a fossil fuel energy source may not be sustainable. We now realize how unhealthy air pollution from fossil fuels is. We have known for decades now that particulate emissions from power plants have caused cancer and premature death. The Regional Greenhouse Gas Initiative of the northeastern states forced mid-western power plants to clean up their act. As a result, there has been a significant improvement of air quality in these states. Who paid for the power plant technology to remove particulates? It was the ratepayers in the mid-west. In this case, we have transferred the northeastern health costs to the ratepayers in the mid-west.

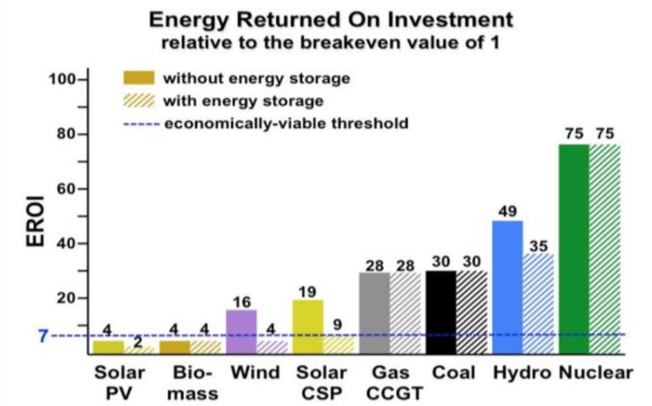
But what about the global warming caused by CO_2, which affects the entire planet? [Did you know that burning 1 ton of carbon produces 3.7 tons of CO_2.] Who will pay? And how? At present there is no man-made technology to remove CO_2 from the atmosphere. That leads us to the idea of finding non-carbon sources of energy, which we define as "renewable". Maryland legislated a Renewable Portfolio Standard[i], which requires electricity suppliers in the state to procure 25% of their electric retail sales from eligible renewable energy sources by 2020. There is a special "carve out" for solar that requires that 2.5% of the electricity generated must come from solar. All of these eligible sources have technical and environmental drawbacks. But solar has caught the attention of the public as a "renewable" source of energy.

As with many technologies, the optimum technology is often not the most cost effective. PVs got their start from the waste stream of the computer industry, where the intense energy investment that transforms silicon into polysilicon had already been made. As the demand for solar panels increased, dedicated manufacturing plants were put into production with the resulting decrease in panel costs. At the same time, the electric efficiency of the panels increased. Currently, the best solar panels convert about 20% of the sun's energy into electricity. The net economic impact of these technical advances has reduced the cost of installing solar panels to the point where the installation cost is dominated by the labor and administrative costs, not the cost of the panels[ii]. The costs bear little connection to their impact on the global ecosystem.

Let's look at whether or not PVs are an optimum environmental solution. First, are they green? When they are placed in operation, they appear to be benign; they do not emit gases, create noise, generate traffic, or make demands on public services. Local zoning protects the landscapes with setbacks and view screening. Thus, they seem to be a perfect solution. But this conclusion ignores the environmental impacts of manufacturing the panels. First, the entire manufacturing process is an extremely energy intensive process. The basic material is mined quartz, which is then refined into metallurgical grade silicon of the sort that is used for hardening steel. Blast furnaces are kept hot consuming mostly fossil fuels and producing CO_2. This silicon is further refined into polysilicon, requiring expenditure of more energy and creating extremely toxic waste byproducts. For every ton of polysilicon, 3-4 tons of toxic silicon tetrachloride are produced. Several manufacturers recycle this waste, but the handling and additional energy adds millions of dollars to the costs. Therefore, some unscrupulous operations just discharge this highly toxic mess into the environment, especially in Asia. New rules require manufacturers to recycle 98.5% of the waste, but enforcement seems to be lax.

This, however, is not the end of the toxic processes. To improve the efficiency of electricity production, cadmium and telluride are added into the polysilicon. Each of these toxic processes may have future technological remedies, but millions of panels have already been produced that will create a highly toxic waste stream when their useful life has ended. In fact, 80 to 90% of PV emissions are generated during the manufacturing process. So what appears to be a clean technology, has really just shifted a dirty problem geographically to someplace else, often where people don't have the power to protest.

Now let us examine the question, are PVs sustainable? Do PVs generate more electricity than it takes to manufacture, operate and decommission them? For various energy sources there is a number, called the Energy Return on Investment (EROI), that compares these two energies. When this number is 1, there is no advantage, since the energy generated is equal to that consumed over its lifetime. If the EROI is less than 1, then effort is wasted, because the energy returned never recovers the energy invested to produce it. The figure below shows this number for various energy sources.



Source: Forbes Feb

When the the cost of oil is about $60 per barrel, an EROI above 7 becomes economically viable. The EROI for PVs is extremely difficult to determine: 4 represents an average number of many sources, having a range of 0.82 to about 8.0. If it truly is below 1, then it is a wasted effort. A consensus has not been reached for the value of EROI for current PVs, but the general consensus is that the EROI for PVs will remain a small number. So there is an international race to find cheaper, easier to manufacture, less polluting sources of non-crystalline PVs. If the energy input to manufacture PVs can be reduced, then the EROI will increase and at least guarantee that the EROI is greater than 1.

So how do we compare a solar installation to farmland? Fortunately, the Intergovernmental Panel on Climate Change (IPCC) has given us given us a pathway to the answer. The IPCC has calculated the carbon intensity of various energy sources, or how much CO_2 is emitted per unit of energy for various sources as shown (from Wikipedia). Solar PVs emit about 20 times less CO_2 than coal or 10 times less than natural gas, but they still inject CO_2 into the ecosystem.

Technology	**Description**	**50th percentile (g CO_2-eq/kWh_e)**
Hydroelectric	reservoir	4
Wind	onshore	12
Nuclear	various generation II reactor types	16
Solar PV	Polycrystalline silicon	46
Natural gas	various combined cycle turbines without scrubbing	469
Coal	various generator types without scrubbing	1001

What about agriculture? Although a direct comparison between PVs and agriculture cannot be made on an energy basis, studies have estimated the net flux of CO_2 from agricultural lands. The 2014 IPCC report devotes an entire chapter to this discussion. Clearly fossil fuels are used by farm machinery, for production of fertilizers, etc. However, there is a major difference between agriculture and PVs. Agriculture has the potential to be a major carbon sink. Currently, the IPCC estimates that the net global agriculture production of CO_2 is about zero. That is, the CO_2 generated in production is balanced by the amount it sequesters. Many IPCC recommendations for improving carbon sequestration in soils are already employed in Maryland, such as min-till, no-till, cover crops, forage crops and organic farming. Thus, in Maryland, many farms are sequestering CO_2 instead of generating it. Improving agricultural practices globally has the potential to sequester far more carbon than any other method of sequestration. The IPCC estimates that agriculture has the potential to sequester between 10 and 15% of the global CO_2.

Current PVs will never be totally green or totally sustainable. Improved technology will find ways to solve the major issues with toxic production and increase the efficiency of electricity production. The dream of building truly sustainable "solar breeders", namely solar powered plants to produce solar panels is not currently cost effective largely because the intensity of the sun is not sufficient to meet the high energy demand required.

Returning to the original question of whether or not we should place solar photovoltaics on agricultural lands, the answer clearly is NO! It makes no sense to replace agricultural lands, a net sink of CO_2, with PVs, a net producer of CO_2. However, it does make sense to put PVs on land and buildings that do not have the potential to be carbon sinks. So PVs do have their place in the current strategy to reduce the injection of CO_2 into the atmosphere. Strategies that reduce the production of CO_2 should be pursued, but a natural process that sequesters CO_2 should receive a higher priority over reducing CO_2 production. Displacing farmland with solar PVs makes **<u>no</u>** sense.

[i] The eligible sources are: Solar Water Heat, Geothermal Electric, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Geothermal Heat Pumps, Municipal Solid Waste, Landfill Gas, Tidal, Wave, Ocean Thermal, Wind (Small), Geothermal Direct-Use, Anaerobic Digestion, and Fuel Cells using Renewable Fuels. Some challenge whether some of these energy sources are truly renewable.

[ii] The recent import surcharge on solar panels and the loss of tax credits in 2019 may change this cost ratio.