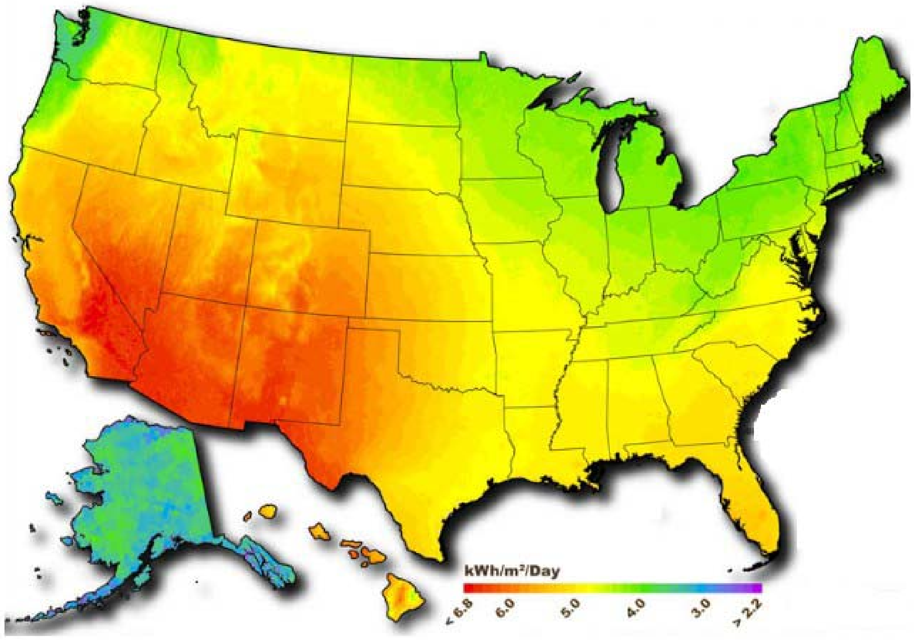
ANOTHER LOOK AT THE ECONOMICS OF PHOTOVOLTAIC CONVERSION OF SOLAR ENERGY

The recent events in Japan will probably set-back the use of nuclear energy for electricity generation by a decade or more. In the meanwhile there appears to be sufficient fossil fuel supplies(especially coal and gas)available to muddle through into the near future despite of the clear rise in costs of these available energy sources and their possible contribution to global warming. If the nuclear option cannot be revived because of political and economic reasons and also the recovery of fossil fuels becomes economically prohibitive, then one needs to go to renewable energy sources such as wind , biofuels, and solar. Of these renewable sources, solar energy via photovoltaic energy conversion appears to be most promising. This energy source is plentiful throughout much of the world but has the disadvantage that one is dealing with a very diffuse energy source requiring multiple square kilometers just to supply a large city with its energy needs.

We want here to re-look at the economics of solar energy using photovoltaic conversion in order to see if it would make sense as a viable and economic energy source.

Let's begin with an examination of presently available photovoltaic flat panels. These all tend to be relatively small of about 2m^2 area generating about 200 watts in full sunlight. Their cost is about $400 per panel which is equivalent to $2 for every watt generated. With full sun the photovoltaic panels tilted at an angle of the local latitude from the horizontal will receive on average about six hours worth of 1kw/m^2 of solar irradiance. That is (on a sunny day), a typical small 2m^2 photovoltaic panel will generate 1.2 kilowatt hours of electricity at a typical 10% conversion efficiency. Keeping in mind that full sun on such photovoltaic panels exists for only a fraction of the day and year, one must use the more realistic figure of watts per square meter per day averaged over a year. The following map will be useful for this purpose-

ANNUAL AVERAGE OF SOLAR IRRADIANCE ON A PHOTOVOLTAIC PLATE TILTED AT THE LOCAL LATITUDE(source-http://www.nrel.gov/gis/solar.html)



Here in Gainesville the average solar irradiance is equivalent to about 5 kWh/m^2/day and with a 10% conversion efficiency will actually produce just 0.5kWh/m^2/day of electricity. Plastering my entire roof of 300 m^2 with photocells and assuming no installation cost would presently run about $200x300=$60,000. These roof panels of photovoltaic cells would thus generate-

$$0.5\frac{kWh}{m^2/day}\cdot 300m^2.\left[365\frac{days}{year}\right]=54{,}750kWh\ per\ year$$

On my latest utility bill I am paying $77.94 for 654kWh of electricity. That is about 12cents per kWh so that the roof generated electricity could be sold back to my utility for $6570 per year. Since my yearly consumption of electricity for 2010 was 13,480 kWh, it is clear that covering just one-fourth of the roof with photovoltaic cells would be sufficient to meet my electricity needs provided that the utility will buy back some of the electricity generated during full sun and furnish me the extra needed electricity during cloudy days and at night. It would take about ten years to recover the cost of the $15,000 installation involving an area of 75m^2 photovoltaic cells.

From the above discussion it seems that photovoltaic energy conversion can be economic and should become even more so if the efficiency of solar cells can be improved and their costs can be further reduced using thin sheets of polycrystaline cells. Efficiences of 30% should be possible and the use of non-movable solar concentrators requiring a smaller area of PV cells for the same amount of electricity generated seem to lie in the realm of possibilities. As to scaling up to very large photovoltaic plants, this may prove to be economic for desert areas such as Arizona and New Mexico(see above map)but unlikely to become a reality in the more populated areas of the country because of land costs. It would make no sense to build a large photovoltaic plant in areas such as Kansas or Iowa where the land can be put to much better use for growing crops.

Starting from scratch, the cost of a one square mile photovoltaic solar conversion plant in the southern Arizona desert, including land purchase, assembly costs, and photo cells would be about a billion dollars. It would generate about 2 million kWh per day. At the present cost of electricity, it would take about 14 years to pay off the plant if no interest is charged on the construction loans. Since such a large scale solar plant would have the same problem of intermittent sunlight as roof units have, some form of backup will be required in the form nuclear and/or fossil fuel generated electricity. It seems that the optimum approach will be to the generate the photovoltaic power locally as discussed above (ie-on one's roof) and thereby reduce the electricity demand on the local utility and decrease pollution levels.