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The unstoppable rise of photovoltaic solar energy: PV vs. PV

Antonio Luque
Instituto de Energía Solar, Universidad Politécnica de Madrid, Spain

Photovoltaic (PV) solar energy has been growing during the last decade an explosive rate. Last year (2011) the solar cell production amounted to more than 37 GW. It is the energy technology most installed nowadays. The power generated by the 37 GW is similar to the one generated by about 7 nuclear units of 1 GW each. The solar industry is already a huge industry dominated by Asian countries led by China. It is not anymore a promise. It is just a reality.

Why has this been produced? The trend for sustainability is not utopia; it is an urgent need. At least two billion of human beings will share with the one billion of citizens in the world richest countries formerly developed countries their consumption patterns that were already deemed unsustainable for the privileged one billion. In certain cases recycling will substitute mining for some materials. For energy coal, oil or gas will be eventually exhausted at, least at the low prices that make them so attractive. Uranium 338, the only natural fissile material will also be exhausted, although fertile materials, if an adequate flux of neutrons is provided, can become fissile so extending the availability of nuclear electricity. But, as with materials, their use generates wastes, which in the case of energy are unrecoverable. They are just heat with no useful energy.

Only the energy of the sun reaches us in huge amounts and exceed in thousands of times our energy thirst. Actually it has been forever the origin of most of our energy: wood and fossil fuels. But it is also our source food; for it we are using today about 13% of the emerged lands. The efficiency of conversion of solar energy into edible calories is very low, in the range of 0.03% and it is also too low for a substantial the conversion into fuels, which would compete with food. The same low conversion efficiency problem appears for the wind energy, again derived from the solar energy of for the hydropower or for wave and steam energies in the oceans. Only the direct conversion has today high efficiencies of about 5% with respect to the land and will reach 10% in few decades. The amount of land for its massive exploitation will be negligible (below 0.2% of the emerged lands for 1/3 of the world electricity)

How has it happened? The discovery of effects of light on electricity was first reported by Alexandre Edmond Becquerel (the second of the saga) in 1839. Only

in 1905 was Albert Einstein able to give an explanation. In 1954, Chapin, Fueller, and Pearson produced the first effective silicon cell; a couple of years later, Si solar cells were incorporated in Russia to the Sputnik satellites. In 1973, with the first oil shock, an industry started to be built that grew unnoticed until the recent years in which an explosion was produced. An important driving force was the feed-in tariffs, established first in Germany, but adopted with success in Spain and other countries. In 2008, Spain installed 2.5 GW of power plants while until then most of the applications had been small and localized. By the end of this year the 40 of the 50 biggest PV plants in the world, including the largest one (Olmedilla of 60 MW) were installed in Spain. No electric generating technology can be installed so quickly! In this moment (August 11, 2012) the largest plant, of 214 MW is in India followed by one in the USA of 200 MW. Spain has no support now for PV but Spanish companies are installing large plants in USA, of more insolation, (eg. Abengoa 200 MW) and there are plans for building such plants also in Spain to deliver electricity at the spot price.

One of the advantages of PV is that solar cells can be made with many technologies. In 2002 I invited to Cercedilla, in the Madrid Mountains, three dozen of experts (including Nobel Laureate Alferov) to look for drastic increases of efficiency in solar cells. A book was published [1] and a project (FULLSPECTRUM) was proposed to the European commission involving 19 European research centers (including Ioffe Institute) that was granted coordinated by myself. One of the topics of research was the Multiple junction solar cell which is a sophisticated device containing a monolithic (that is, in a single crystal) stack of several cells (three today) of different bandgaps each one appropriate for a range of photon energies. By the end of the project the European team snatched (for a short period) the world efficiency record to the USA. As a consequence of the project an institute for concentrator PV systems (the sophisticated multijunction cells must operate under concentrated sunlight) was established that supported the installation, for the first time, of 3 MW of triple junction solar cells operating under concentration. The companies selected for this action and initiated in it are today the most successful in the market, which is still incipient.

Other subject studied in this project was the Intermediate band solar cell that attempts to make a triple junction solar cell by forming an energy band (the intermediate band) within the bandgap. The concept has been proposed by us (Luque and Martí) in 1997 [2] and is researched today by many groups (the paper has today 555 WOK citations). Progress in this technology can be found in reference [3].

I believe that this technology, due to its hight efficiency, above 40% and able to reach 50%, has the potential generating PV electricity cheaper [4] than any other solar or non solar technology. However today is more expensive that the

well established Si technology; so, its adversary is PV; this is a case of PV vs. PV. We expect that if the concentrator PV develops, maybe with some political help, its faster learning potential due to the increase of efficiency and to the many options available for the optics and the mechanics, will lead to prices that will be soon below those of the ordinary PV. It should become the leading technology for power plants in regions of high insolation.

Ultimately we expect that in one or another way PV will supply by the mid of the century 1/3 of the electricity consumption worldwide. This can be absorbed by a good electric grid system. In spain we are already accommodating 16% of wind energy and over 3% of PV energy in annual basis. 33% should be achievable. But beyond this cheap storage means will be necessary to increase the proportion of solar electricity and these are not yet available

References

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