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Theoretical Limits of Photovoltaic Conversion

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4.1 INTRODUCTION

Efficiency is an important matter in the photovoltaic (PV) conversion of solar energy because the sun is a source of power whose density is not very low, so it gives some expectations on the feasibility of its generalised cost-effective use in electric power production. However, this density is not so high as to render this task easy. After a quarter of a century of attempting it, cost still does not allow a generalised use of this conversion technology.

Efficiency forecasts have been carried out from the very beginning of PV conversion to guide the research activity. In solar cells the efficiency is strongly related to the generation of electron–hole pairs caused by the light, and their recombination before being delivered to the external circuit at a certain voltage. This recombination is due to a large variety of mechanisms and cannot be easily linked to the material used to make the cell. Nevertheless, already in 1975 Lofersky [1] had established an empirical link that allowed him to predict which materials were most promising for solar cell fabrication.

In 1960, Shockley and Queisser [2] pointed out that the ultimate recombination mechanisms – impossible to avoid – was just the detailed balance counterpart of the generation mechanisms. This allowed them to determine the maximum efficiency to be expected from a solar cell. This efficiency limit (40.7% for the photon spectrum approximated by a black body at 6000 K) is not too high because solar cells make rather ineffective use of the sun's photons. Many of them are not absorbed, and the energy of many of the absorbed ones is only poorly exploited.

Revisiting the topic of efficiency limits is pertinent because today there are renewed attempts to invent and develop novel concepts in solar cells – sometimes known as

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